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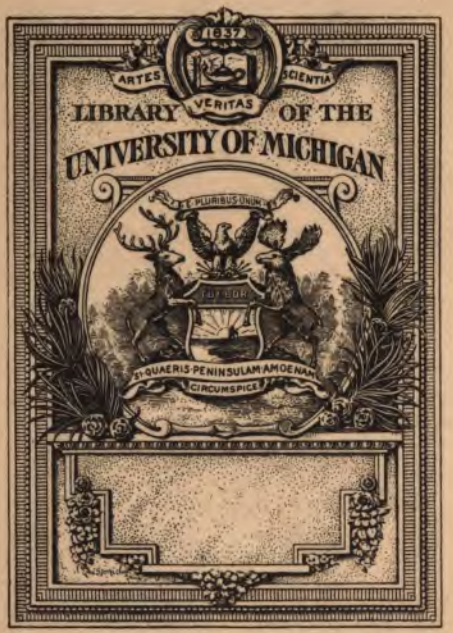
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AN EXPERIMENTAL INVESTIGATION OF THE NORMAL MIND IN MEN AND WOMEN

BY

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AUTHOR'S NOTE.

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H. B. T.

CHICAGO, July 12, 1902.

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worthy so far as it goes. Previous experimental work has been in the form of detached experiments on some single sense or intellectual process. Usually the experiments have not been made for the purpose of a comparison of the sexes, but have been performed with some other interest in view, and have been incidentally formulated with reference to sex. Much of the material is the experimental work on school children done under the influence of the child-study movement. The only previous attempt to sum up the experimental evidence on the subject is that by Havelock Ellis (23),[1] in his book *Man and Woman*, published in 1894. The work contains no original investigation.

In making a series of tests for comparative purposes, the first prerequisite is to obtain material that is really comparable. It has been shown that the simple sensory processes vary with age and with social condition (11, 20, 51, 54, 63, 64, 65, 67). No one would question that this statement is true for the intellectual processes also. In order to make a trustworthy investigation of the variations due to sex alone, therefore, it is essential to secure as material for experimentation, individuals of both sexes who are near the same age, who have the same social status, and who have been subjected to like training and social surroundings. The complete fulfilment of these conditions, even in the most democratic community, is impossible. The social atmosphere of the sexes is different from the earliest childhood to maturity. Probably the nearest approach among adults to the ideal requirement is afforded by the undergraduate stu-

[1] The numbers which appear in parentheses throughout the text refer to the bibliography at the end of the volume.

dents of a coeducational university. For most of them the obtaining of an education has been the one serious business of life. They have had at least the similarity of training and surroundings incident to school life. Most of those in a western university have received their preparatory education in coeducational schools.

The individuals who furnished the basis for the present study were students of the University of Chicago. They were all juniors, seniors, or students in the first year of their graduate work. The original intention was to limit the ages to the period from twenty to twenty-five years. Owing to the difficulty of obtaining a sufficient number of subjects within these limits, a few individuals of nineteen years, and a few over twenty-five were admitted (see Fig. 81). The subjects were obtained by requesting members of the classes in introductory psychology and ethics to serve. They were told nothing about the object of the tests except that they were for the purpose of determining psychological norms. The series of questions on age, health, and nationality, reported in chap. viii, shows that in all these respects the men and women tested were closely comparable.

Two methods may be followed in planning a series of tests designed to yield material for the comparison of groups or classes. It is possible either to make rapid and more or less superficial measurements on a large number of individuals, depending on numbers to counterbalance the errors of single tests, or to make careful and accurate observations of a smaller number of persons. The ideal procedure would unquestionably be to make careful measurements of a large number of individuals, but since the amount of time

available for any problem is limited, the practical question to be decided is—Given a limited amount of time, which of the two modes of procedure mentioned is more likely to yield valuable results? Accuracy of measurement seemed an indispensable requirement for such a study as the present one. Any reliable determination of a threshold or a discriminative sensibility requires a somewhat extended series of experiments. With subjects untrained in psychological experiments —as most of these were—it is essential to take a large enough series of measurements to give some assurance that the results represent a characteristic reaction, and not haphazard answers. In so simple a test as that of dermal two-point discriminations the first few judgments are very likely to be little more than guesses. In a series of rapid tests like those employed at Columbia University (82) the subject is given only five stimulations with the æsthesiometer. The points are kept a fixed distance apart and the subject is given both one- and two-point stimulations in his series of five. It seems improbable that the results of such a test on unpracticed subjects mean anything more than random answers. The Columbia experiments on a large number of students failed to reveal any difference of sex in the fineness of two-point discriminations, while the present accurate measurement of fifty subjects shows a clear difference.

The series of tests employed in this investigation required from fifteen to twenty hours of time from each subject. The hours were arranged from one sitting to the next according to the convenience of the subject. It was not possible to have the hours for any one test constant for all subjects, since the

schedules varied so widely No attempt was made to keep the order of experiments rigidly the same for all. Convenience and economy of time necessarily determined the order to a great extent. In general, however, the simple sensory and motor tests were given in the early part of the series, and the intellectual tests in the latter part. The questions on personality usually came last. The taste and smell experiments had to be scattered through most of the periods, since only a few at a time could be performed without fatigue. The entire series was applied to fifty subjects, twenty-five men and twenty-five women.

The experiments fell into seven groups, dealing respectively with motor ability, skin and muscle senses, taste and smell, hearing, vision, intellectual faculties, and affective processes. One chapter of this monograph is devoted to each group. A list of the experiments under each group will be found at the beginning of each chapter. At the end of each chapter there is a comparison of results with those of other investigators, and a general summary. The numbers in parentheses used in the summaries of other experimental work and throughout the text, refer to the bibliography at the end of the volume. The bibliography pretends to completeness only in its enumeration of the experimental researches bearing on the problem, and even here there are doubtless omissions, although it is hoped that all the important papers are mentioned. Whenever for the sake of brevity a dogmatic statement is made to the effect that there are no data on a certain point, or only such data as are quoted, the qualification, *so far as the author knows*, is to be understood.

The report of each experiment includes a description of the apparatus used, a statement of the method, and a formulation of the results. Since the value of experimental work, and the possibility of comparing one set of results with another depend so largely upon the method, the greatest pains has been taken to secure uniformity, and to describe the method in full in each case. The experiments were all performed by the author, with the exception of a part of the reaction-time tests, which had to be repeated because of a source of error in the apparatus. For these the author is indebted to Dr. W. C. Gore and Mr. H. J. Pearce, of the Graduate School of the University of Chicago.

A few words in general on the methods employed may not be out of place, in spite of the fact that each is described in full in connection with the test. The guiding principle in selecting the method was the desire to make the directions to the subject as clear and simple as possible and at the same time secure the greatest possible accuracy of result. In all the tests on discriminative sensibility this double end seemed best secured by requiring a simple judgment of comparison (*i. e.*, lighter or heavier, more or less cold, etc.) between two stimuli. The subject was told nothing of a standard stimulus, and the order of the standard and stimulus of comparison was varied. The difference in intensity between the standard and the stimulus of comparison was varied until the point was found at which three-fourths of the judgments were correct. In the threshold tests of taste and smell, tasteless and odorless preparations were used to control the threshold illusions. The greatest care was taken to avoid

suggestion of all sorts in all the tests. The descriptions of method have been made explicit at the risk of their being perhaps somewhat tedious and needlessly detailed.

The results of the experiments have been presented graphically wherever possible. In all the curves, the dotted line is for women and the unbroken line for men. The ordinates always represent the number of subjects. In no case have the results been averaged. Wherever graphic representation was impracticable, they have been grouped. The purpose of the research was norms, not averages.

CHAPTER II.

MOTOR ABILITY.

THE subjects of the tests on motor ability were as follows:

A. Reaction times.
   1. Auditory.
   2. Visual.
B. Rapidity of finger movement and rate of fatigue.
C. Co-ordination.
   1. Formation of a co-ordination. Card-sorting.
   2. Accuracy of a formed co-ordination.
      (*a*) Striking a target.
      (*b*) Precision of movement in drawing lines.
D. Motor automatisms.

A. REACTION TIMES.

Two sets of simple reaction times, the first auditory and the second visual, were taken from each subject. The Hipp chronoscope was used for both. The auditory stimulus was a click in a telephone receiver, made by breaking the circuit. A flash of pale purple light in a Geissler tube served as the visual stimulus. Between forty and fifty reactions of each kind were made by each subject. While reacting, the subject sat alone in the reaction room, placed in as comfortable a position as possible. His right forearm was supported on the table, and the forefinger of his right hand rested lightly on the button of a break key which was in the chronoscope circuit. The telephone for the auditory stimulus was adjusted to the ear of the

subject. The Geissler tube for the visual stimulus was placed on the table in front of the subject. It was suspended before a black background, against which the flash of pale purple light was thrown out sharply. A warning signal consisting of two clicks of a telegraph instrument was given about two seconds before the stimulus. The time was varied slightly to counteract the widespread tendency to premature reactions. The signal for the release of the key after the reaction consisted of one click of the telegraph instrument. The reactions were taken in series of ten to twelve, with four- or five-minute periods of rest between. The subject was given no instructions about the direction in which his attention should be concentrated. He was merely told to make the reaction as nearly instantaneous as possible. After the experiment he was asked in what direction his attention had been concentrated while reacting.

The results are recorded in terms of the mean reaction time and mean variation (74). Series of the first forty-one unquestioned reactions of each kind served as the basis of the calculation. Both the mean reaction time and the mean variation appear in the results in terms of sigma (.001 seconds). The number of subjects represented by each ordinate in the

TABLE I.

Mean variations of reaction times.

		10 σ	12 σ	14 σ	16 σ	18 σ	20 σ	22 σ	24 σ	26 σ	28 σ	30 σ	32 σ	36 σ	40 σ	50 σ	60 σ	70 σ	80 σ	90 σ
Audit.	Women	...	3	3	1	2	3	1	2	1	1	...	...	...	1	2	3	1	...	1
	Men...	. .	3	...	3	6	3	2	2	3	...	1	...	1	...	...	...	...	...	...
Visual	Women	3	2	3	3	2	2	2	2	1	...	...	...	2	2	1	...	...	...	...
	Men...	2	3	1	5	3	3	1	4	...	1	1	...	...	.	...	...	...	...	...

curve is the number whose reaction times fell between the point on the curve at which the ordinate is erected and the next previous one. Thus the number of subjects represented at 150σ is the number whose reaction times fell between 140σ and 150σ.

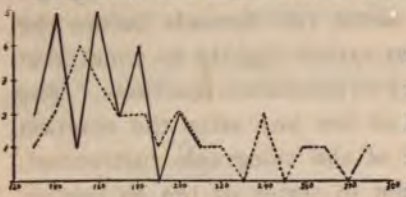

FIG. 1.

Reaction times. Auditory.[1]
Abscissas — sigma.
Ordinates — number of persons.
- - - - women; —— men.

The curves represented in Figs. 1 and 2 show that the men have, on the whole, shorter reaction times than the women. In both auditory and visual reactions there are several men with shorter times than any of the women, and several women with longer times than any of the men. Moreover, the men are decidedly more numerous than the women in the region of short times. The average of the mean variation (Table I) is also smaller for the men than for the women. The difference is not apparent in the lowest ranges. It is shown by the smaller number of women in the middle ranges, and their greater number in the region of very large variations. The fact that the mean

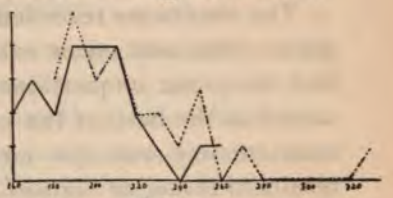

FIG. 2.

Reaction times. Visual.[1]
Abscissas — sigma.
Ordinates — number of persons.
- - - - women; —— men.

[1] It will be noticed that only twenty-four men are recorded in the reaction-time curves. The reason is that in one case in which the results were unreliable because of irregularity in the apparatus, it was impossible to obtain the subject again for a repetition of the experiment.

variations of the visual reactions are in both sexes less than those of the auditory, is doubtless partly due to the fact that the auditory reactions were taken first. The effect of practice is shown in the greater evenness of the visual reactions.

The shorter reaction time of the men is at least partly explained by special training in athletics. The man who made the most rapid reaction both to the auditory and to the visual stimuli was one of the best players on the football team. The other three men who made very quick auditory reactions were track athletes, one a bicycle rider and the other two runners. Two of these latter had visual reactions also which were shorter than the visual reactions of any woman.

The type of the reaction was recorded under one of the three general heads, sensory, motor, and central. The central rubric includes all cases in which the subject reported that his attention had been equally divided between stimulus and movement.

TABLE II.

Types of reaction.

		Sensory.	Motor.	Central.
Auditory.	Women	19	5	1
	Men	13	8	3
Visual.	Women	21	3	1
	Men	11	9	4

There is a decided preponderance of women with a sensory type of reaction. The adherents of the Leipsic school would doubtless say that the shorter reac-

tion time of the men is to be explained by the greater proportion of motor reactors among them. Probable as this theory looks from the tables, it is not borne out by a detailed examination of results. The men with the shortest reaction times were in most cases of the sensory type, while several of the motor type were among those with longest times. The real explanation of the greater frequency of the motor type among men is rather to be sought in the fact that they lead more active lives on the whole than women, and are more interested in learning new movements of various sorts. For this reason their attention is more likely to be directed to the technique of movement than is that of women.

B. RAPIDITY OF FINGER MOVEMENT AND RATE OF FATIGUE.

The apparatus used to ascertain the rapidity of finger movement, and the rate at which the finger becomes fatigued, was a counting machine worked by a rod bearing a disc on which the finger rested. A dial on the front of the machine registered the number of times the rod was pressed. The machine was fastened in a wooden support on a table, with the rod projecting upward. The wooden support was extended into a rest for the arm. The subject sat at the table with his forearm from elbow to wrist resting on the support, and the index finger of his right hand on the disc of the rod. When in this position, every downward movement of the finger pressed the rod down and was registered on the dial of the machine. The arm was bound in position at the wrist and at the elbow to confine the movement as much as possible to

the finger muscles. In spite of this precaution the arm came into play somewhat, particularly after fatigue set in. But although it was impossible to limit the motion strictly to the finger muscles, still they were principally involved, and the conditions were the same for all subjects. In pressing down the rod, the finger was working against a considerable resistance—about that of a stiff-action piano key.

The subject was told that the object of the test was to find out how rapidly he could make the movement. He was not told how long he was to continue it. His only instruction was to start the instant the signal was given, and keep up the movement until he was told to stop. The dial readings were taken every twenty seconds by the second hand of a watch. The subject was stopped at the end of two minutes, if he had not already given out. The movement had by this time become painful in every case. The test was made twice. The second time the subject of course knew that it would have to be continued until it became painful, but he was told not on that account to try to save his strength by going slowly at first, but to go as fast as possible at the start, and let the running-down process take its natural course. The results which appear in the curves are averages of the two tests.

TABLE III.

Finger movement. Endurance, *i. e.*, number of seconds the movement was continued.

Seconds	40	60	80	100	120
Women	1	2	3	2	17
Men	..	..	..	2	23

The results given in Figs. 3 and 4 and Table III, show a striking advantage on the part of the men, both in the initial rate of the movement, and in the ability to sustain it. The men made on an average about ten more taps in twenty seconds than the women. Only two men gave out before the end of two minutes, while eight women did so. One of the two men had had his arm permanently weakened by a fracture. The men had an average of about twenty taps in twenty seconds faster than the women at the close of the test.

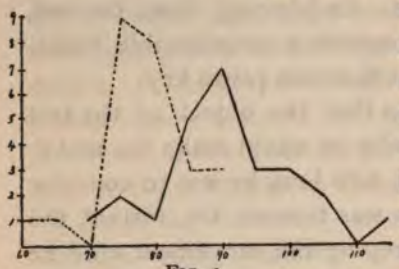

FIG. 3.

Finger movement. Rate during the first twenty seconds.
Abscissas—number of taps.
Ordinates—number of subjects.
- - - - women; —— men.

It is interesting to note in connection with this test that it has been shown by Professor Oscar Reif of Berlin (70) that the rate of movement of the separate fingers is not greater in piano players than in other people. The only way in which piano practice would give an advantage in this test is by increasing endurance through the general strengthening of the hand. In so far as this factor affects the results, it is in favor

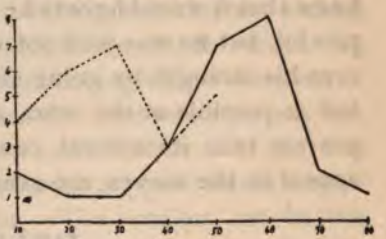

FIG. 4.

Finger movement. Rate during the last twenty seconds.
Abscissas—number of taps.
Ordinates—number of subjects.
- - - - women; —— men.

of the women, since there were more piano-players among them than among the men.

Professor Féré (24) makes the suggestion that probably the force and the rate of voluntary movements vary together. The present series of tests certainly tends to corroborate this theory. The amount of force required for the movement was even at the outset well within the limits of strength for both sexes, but the rate appears constantly as a function of the strength. The same relation between force and rate may account for the faster reaction times of men.

C. CO-ORDINATION.

1. *Formation of a co-ordination.*— The apparatus used for testing the ability to form a co-ordination was one of the boxes of the Jastrow card-sorting apparatus (39). Its four divisions were marked with discs of the four pure colors, red, blue, green and yellow. There were forty cards in the pack, ten of each color. Before each test, the pack was so arranged that no two cards of the same color followed one another. The directions given to the subject were to sort the pack as rapidly as possible, throwing each card into the division marked with its own color, making no stops for mistakes and no attempt to correct them. The signal to start was the word "go," after a count of three. The time was taken with the second hand of a watch. The test was made three times for each subject. To shut out the effects of practice and insure a fresh co-ordination each time, the colors on the divisions of the box were arranged differently for each trial. The results are given in terms of the average time of the three trials in seconds and the average number of mistakes.

The curves for the card-sorting test (Figs. 5 and 6) show that the women are decidedly more rapid than the men. The best record is that of a woman. The women's mean rate is about two seconds faster than that of the men, and there are several men with longer times than any woman. The women have also a somewhat higher degree of accuracy than the men.

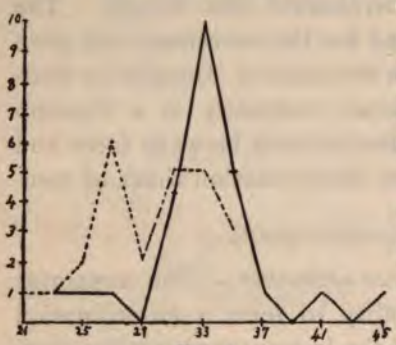

FIG. 5.

Card-sorting test. Rate.
Abscissas — time in seconds.
Ordinates — number of subjects.
---- women; —— men.

To ascertain whether or not the handling of playing cards gave an advantage to the card players in this test, the subjects were questioned as to their habits of card-playing. The fact that those who made the best records, both men and women, were people who played cards very little or not at all, indicates that practice in card playing is not of great importance in this test. In so far as it is a factor, it would be in favor of the men, since there were more card-players among them than among the women.

In two cases of abnormal slowness among the men, a decided color-blindness is doubtless responsible. None of the subjects were so color-blind that they could not distinguish between the pure colors used on the cards, but in the two worst cases of color-blindness the discrimination was probably slower than the normal. The subject with the longest time reported a feeling

of slowness in recognizing the colors, but none of the others were conscious of this difficulty. That the poorer color discrimination of the men (see Fig. 47) could account for their slowness in sorting the cards is impossible, since there proved to be no co-ordination between the rate of card-sorting and the fineness of color discrimination. Several subjects with excellent color discrimination were slower than the average, while several of those with slight partial color-blindness were much faster than the average.

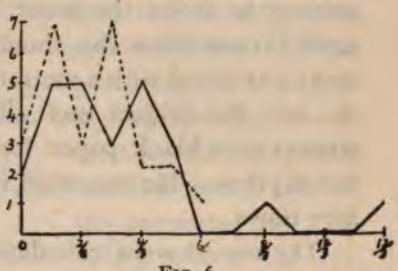

FIG. 6.

Card-sorting test. Accuracy.
Abscissas — average number of mistakes.
Ordinates — number of subjects.
- - - - women; —— men.

The two factors of time and accuracy showed no co-ordination. Some subjects with the shortest times had also the highest degree of accuracy, and some with the longest times were very inaccurate.

2. *Accuracy of a formed co-ordination.*—The first of the tests on the accuracy of a formed co-ordination consisted in striking at the center of a target with a rapid free-arm movement. The target was a sheet of paper on which were inscribed nine concentric circles. The central circle had a diameter of 2 cm., the next one 4, the next 6, etc., giving a total diameter of 18 cm. to the target. The four radii at right angles were marked at each intersection with a circle, with the number of millimeters from the center; the first one 10, the second 20, etc. The target was hung on the wall at such a height that its center was on a level

with the hand when the arm was stretched out straight from the shoulder. The subject then took his stand at such a distance that when his arm was extended before him the point of a pencil held in the hand just touched the center of the target. He was required to attempt to strike the inner circle with the pencil, in rapid thrusts from the shoulder. The rate of movement was timed with a metronome. Before beginning the test the subject was allowed to practice a few strokes on a blank paper for the purpose of learning the rhythm. He was then required to hit the target fifty times.

The results were calculated by counting the number of strokes which fell within each successive 5 mm. section of the target, measured from the center along the radii. Table IV gives the results in full, in terms of the percentage of dots falling within each section of the target.

TABLE IV.

Target test. Percentage of the total number of dots falling within each of the first four sections of the target.

Secs.		5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%
0–5	Women	..	..	..	5	2	3	6	3	1	3	2
	Men	..	..	3	2	1	1	4	3	3	6	2
5–10	Women	..	..	..	..	1	5	11	2	3	1	2
	Men	..	..	..	..	3	4	8	7	3	..	..
10–15	Women	..	4	5	8	6	2	..	..	..	..	..
	Men	..	3	4	9	5	3	1	..	..	..	..
15–20	Women	8	7	3	6	..	..	..	..	..	..	..
	Men	12	5	3	5	..	..	..	..	..	..	..

The general outcome of the test may most readily be seen by comparing the two curves (Figs. 7 and 8) plotted from Table IV. The first one is a graphic representation of the percentage of dots falling within the innermost section (*i.e.*, 5 mm.) and the second one of the percentage of dots falling within the 15–20 mm. section, which was the outermost one in which all subjects (except one) placed dots. The first curve shows a greater number of women than men with small percentages of dots in the center of the target, and a greater number of men than women with large percentages. The second curve shows the reverse to be true for the outer section of the target. The men with small percentages are somewhat more numerous than the women, and the women with large percentages than the men. The two curves agree in showing better co-ordination on the part of the men. Table V,

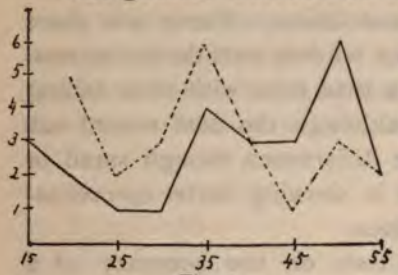

Fig. 7.

Target test. Percentage of dots falling within the 5 mm. section of the target.

Abscissas — percentage of dots in 5 mm. section.

Ordinates — number of subjects.

---- women ; —— men.

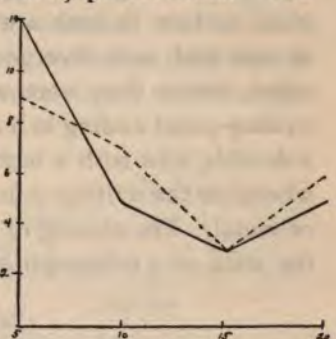

Fig. 8.

Target test. Percentage of dots falling within the 15–20 mm. section of the target.

Abscissas — percentage of dots in the 15–20 mm. section.

Ordinates — number of subjects.

---- women ; —— men.

showing the range of the dots farthest from the center, corroborates this conclusion. There are more men than women who put no dots outside the 20 mm. circle, and more women than men with dots falling beyond 20 or 25 mm., although the best record was that of a woman. The differences, though small in each case, are in accord in showing better co-ordination on the part of the men.

The second of the tests on the accuracy of a formed co-ordination was made with an apparatus modeled after that used by Bryan (11) in his tests on school children for determining the precision of movement. This apparatus, however, was made on a much larger scale than Bryan's, and was used for free-arm movements instead of finger movements. It consisted of two thin strips of copper 21 cm. long fastened to a glass surface in such a way that they were in contact at one end, and diverged very gradually toward the other, where they were about 5 mm. apart. A brass writing-point ending in a small knob was connected by a flexible wire with a battery whose circuit was closed whenever the writing-point touched either of the strips of metal. The closing of the circuit was announced by the click of a telegraph instrument. The point where

TABLE V.

Target test. Outer limits of dots on the target.

		Sections of Target.							
		5	10	15	20	25	30	35	40
Outer limit.	Women	..	..	1	6	9	5	3	1
	Men	..	..	..	10	8	4	3	..

the strips of metal were such a distance apart that the knob of the writing-point when placed on the glass between them just made the contact with both strips of metal, was called the zero point. From the zero point to the ends of the strips millimeter scales were marked on both pieces of metal. The total length of the scale was twenty cm. The glass on which the metal strips rested was sunk into a board and set with putty on a level with the surface of the board. The board thus afforded a support for the hand in making the movement.

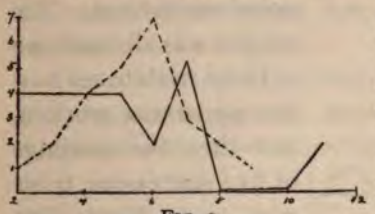

FIG. 9.

Precision of movement test. Right hand, toward.

Abscissas — scale readings, in centimeters.

Ordinates — number of subjects.

---- women; —— men.

For the first test the subject was seated at a table with the apparatus before him in such a position that the strips of metal converged toward him. He was told to start at the twenty cm. point of the scale and attempt to draw a line on the glass between the strips of metal without touching either one. In this position the movement was, of course, toward the body. The subject was allowed to hold the writing-point as he chose, and take his own rate of movement. The only regulation was that the movement

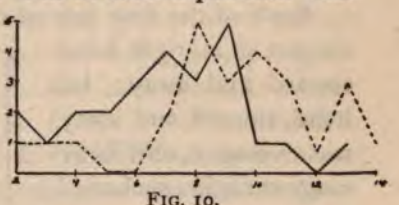

FIG. 10.

Precision of movement test. Left hand, toward.

Abscissas — scale readings, in centimeters.

Ordinates — number of subjects.

---- women; —— men.

must be continuous from start to finish, and must be a free-arm and not a finger, wrist, or elbow movement. As soon as a click of the telegraph instrument indicated a contact, the subject stopped and began again. The point on the scale where the click occurred was noted each time. The subject was allowed two or three trials to see how the apparatus worked, and then the readings of five successive trials with each hand, first the right and then the left, were taken. For the second test the apparatus was turned around, and the movement was made away from the body five times with each hand.

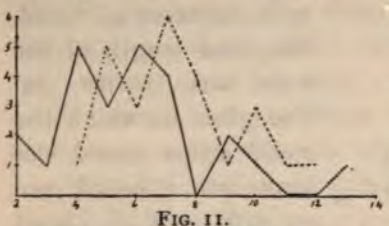

FIG. 11.

Precision of movement test. Right hand, away.

Abscissas — scale readings, in centimeters.

Ordinates — number of subjects.

- - - - women; —— men.

Each of the four sets of results obtained from each subject (*i. e.*, right hand, toward and away; left hand, toward and away) was averaged, and its average variation reckoned.

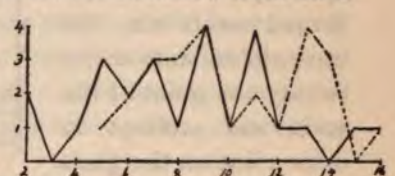

FIG. 12.

Precision of movement test. Left hand, away.

Abscissas — scale readings, in centimeters.

Ordinates — number of subjects.

- - - - women; —— men.

In all four movements the men have a somewhat greater degree of precision than the women (Figs. 9–12). The right-hand movements are better than the left for both sexes, and the movements toward the body better than those away from it.

The average variations (Table VI) for the sexes approximate one another more closely than the averages. In the movements away from the body neither sex can be said to have greater uniformity. In the movements toward the body the variation of the men is somewhat less wide than that of the women.

TABLE VI.

Precision of movement. Average variation of five trials.

		0.5 cm.	1.0 cm.	1.5 cm.	2.0 cm.	2.5 cm.	3.0 cm.	3.5 cm.	4.0 cm.	4.5 cm.	5.0 cm.
Right, toward	Women.	1	3	6	2	4	2	3	2	..	2
	Men....	2	6	6	6	4	1	..	..	..	..
Left, toward	Women.	..	1	3	8	4	6	2	..	1	..
	Men....	..	4	5	3	7	2	2	1	..	1
Right, away	Women.	..	3	8	4	5	2	3	..	..	..
	Men....	..	4	6	4	6	2	1	2	..	..
Left, away	Women.	..	..	1	9	5	3	3	2	..	2
	Men....	..	..	5	4	5	2	3	3	2	1

D. MOTOR AUTOMATISMS.

The object of the test on motor automatisms was merely to discover whether or not a tendency toward automatic movements was present in the subject. The apparatus employed was that used by Miss Stein (76) in her experiments in this field. It consisted of an oblong board suspended from a hook in the ceiling by ropes attached to its four corners. When adjusted, the board hung in a horizontal position about two inches above the surface of a table, on which was

placed a large sheet of rough manila paper. The subject sat at the table with his right arm, from wrist to elbow, resting on the board. He held in his hand, which hung over the edge of the board, a soft black lead pencil, whose point rested lightly on the paper. The board responded instantly to any movement of the arm. Each movement was registered on the paper by means of the pencil.

The instructions given the subject were to place himself in a perfectly comfortable position, such that the arm would have no tendency to move through strain, and then to let his arm do as it pleased,—move if it wished or stay still if it wished,—not to inhibit any impulses to movement which arose, nor make any voluntary movements. The subject's attention was distracted during the test by asking him the series of questions on personality given in chap. viii. These questions proved to be a very efficient method of distraction, since the subjects were universally interested in them.

The results were classified under four heads, with reference to the presence of automatisms, *i. e.*, Absent, Doubtful, Present, and Marked. The cases where no movement was registered, or only such movement as was evidently due to slight changes of position, were marked "absent." Those where the amount of movement was greater, but still possibly due to changes of position, or to gradual accommodation to slight strain, were called "doubtful." Cases where the movements were unquestionably automatic arm movements, but slight in extent and number, were marked "present," while those having movements of considerable extent and variety were classified as "marked."

TABLE VII.

Prevalence of motor automatisms.

	Absent.	Doubtful.	Present.	Marked.
Women.....	8	5	5	7
Men.....	9	6	6	4

The results, given in Table VII, show a somewhat greater tendency on the part of women to display motor automatisms than on the part of men. The tendency is shown most clearly in the last column of the table.

SUMMARY OF OTHER EXPERIMENTAL WORK ON MOTOR ABILITY.

There are several researches on reaction time to compare with the present experiments. Lewis (46), after experimenting on a large number of American men and women, using both visual and auditory reactions, found that men are quicker than women in both kinds of reaction, and have a smaller mean variation. The Columbia University tests (82) included five auditory reactions for each subject. In these the women were slower than the men. The remaining reaction-time tests of which we have a record were made on children. Gilbert (30) has shown that boys are quicker than girls at all ages in auditory reaction, and that boys of over ten years have a smaller mean variation than girls. MacDonald, from his work on the school children of Worcester, Mass. (55, p. 1106), reports a longer reaction time for girls of all ages. Herzen (33, Appendix), from a much less extended series of observations than those on school children, concludes that young girls are quicker in their reac-

tions than boys, but that after adolescence the relation is reversed. As far as adults are concerned, therefore, the experimental evidence agrees unanimously with the present series of tests in showing that men have a shorter reaction time and a smaller mean variation than women. The same relation as to rate probably holds for children.

The only comparable tests on the rapidity of finger movement and the rate of fatigue are those performed on school children by Bryan (11, p. 173), Gilbert (30), and Bagley (3); and those reported by MacDonald (55, p. 1105). They are all in accord with the series of tests here reported in finding greater rapidity of finger movement among males than among females. Gilbert also reports that boys are somewhat less easily fatigued than girls, a conclusion which is again in accord with the present results. The Columbia University tests (82) on fatigue show no difference between men and women in this respect. But in this case the experiment was performed with Cattell's ergometer and the subject was required to make fifty pressures on the instrument at the rate of one a second, conditions certainly not so well calculated to produce fatigue as those of the tapping test. The failure to indicate any sexual difference in fatigue may be due to the fact that the amount of fatigue induced by the experiment was so slight. In the tests recently made on Chicago school children (18) the boys surpassed the girls in both strength and endurance at all ages.

Bagley (3) in his experiments on school children used the card-sorting test in several forms as a test of mental ability. He reports that he found girls some-

what superior to boys in mental ability—a result which is in accord with that of the present test on card-sorting. Another experiment which, although not directly comparable with the card-sorting test, is still of the same type, is the one called a test for the rate of perception in the Columbia University series (82). The subject was given a card containing five hundred printed letters, of which one hundred were A's, arranged haphazard, and was asked to mark out all the A's as rapidly as possible. Here, again, the women were more rapid than the men. The essence of the test in this case also is the formation of a new eye-hand co-ordination.

Both Bryan (11, pp. 192–6) and Bagley (3) find boys slightly superior to girls in precision of movement. Bryan's test was, like the present one, the drawing of a single straight line. Bagley's consisted in tracing a pattern. Bryan also found boys slightly superior to girls in a target test. All these tests on the accuracy of a formed co-ordination agree in showing the male child and adult slightly superior to the female.

The experiments on involuntary movements, and movements influenced by the sight of moving objects carried on by Tucker (81, p. 404) with Jastrow's automatograph revealed no difference of sex in children. Miss Stein's experiments (76) on college students, in which she used the same apparatus which was used in the present tests, produced results which are in accord with those given above, in so far as they are comparable with them. She finds a somewhat greater proportion of women than men who display spontaneous motor automatisms.

GENERAL SUMMARY OF EXPERIMENTS ON MOTOR ABILITY.

All the tests on motor ability of which we have record agree in showing that in most phases this ability is better developed in the male than in the female. Men have a shorter reaction time, with a smaller mean variation than women. They have a greater rapidity of movement than women, and become fatigued less rapidly. They have a somewhat greater accuracy of movement than women. Women excel men in the formation of a new motor co-ordination, such as that of card-sorting and of marking out A's, and are slightly more subject to motor automatisms than men.

CHAPTER III.

SKIN AND MUSCLE SENSES.

THREE groups of problems connected with the skin and muscle senses were investigated; touch and pressure, cutaneous space, and temperature. The subjects under each heading were as follows:

A. Touch and pressure.
   1. Threshold of impact on the volar side of the forearm.
   2. Threshold for pain through pressure on the right and left temples.
   3. Discriminative sensibility for pressure on the palm of the hand.
   4. Discriminative sensibility for lifted weights.

B. Cutaneous space.
   1. Discrimination of two points crosswise and lengthwise on the volar side of the forearm.
   2. Discrimination of areas on the volar side of the forearm.

C. Temperature.
   1. Discriminative sensibility at the physiological zero. Standard, 30° C.
   2. Discriminative sensibility for cold. Standard, 5° C.
   3. Discriminative sensibility for heat. Standard, 45° C.

A. TOUCH AND PRESSURE SENSATIONS.

1. *Threshold of impact.*—The piece of apparatus used in the determination of the threshold of impact was one designed by Professor James R. Angell for use in the laboratory of the University of Chicago (1). In brief, the instrument is a delicate balance, and the stimulus is given by a cork surface at the end of a rod suspended from one arm of the balance. So long

as the amount of fall of the balance arm and the weight producing the fall are constant, the force of the impact must be constant. The instrument is noiseless, and the stimulations can be given at any rate desired.

The area used in the present investigation was the middle of the volar side of the right forearm. The middle point between the wrist and the elbow was marked with an ink spot. The arm was then adjusted on padding under the balance arm; a flat uniform area, if possible with no hairs, was selected close to the ink spot; and the balance arm was brought over this area. The cork surface was raised 3 mm. above the area, and a trial weight of 20 mg. placed in the weight pan. The stimulations were given in series of ten, with intervals of from twenty to sixty seconds between stimulations. Any rhythmic regularity in the series was carefully avoided. The subject was directed to count aloud every time he felt the stimulations—one for the first, two for the second, etc. The point at which he could count seven or eight in ten correctly was taken as the threshold. Not more than three series in succession were given without a rest and change of position.

This test was made in combination with the one for the absolute threshold for vision (see chap. vi, sec. A). The subject was obliged to have his eyes completely protected from the light for three-quarters of an hour before the threshold for light could be tested. This time was used for the determination of the touch threshold, and the discriminative sensibility for area (see sec. B, 2, below). During the entire test, therefore, the subject sat with his head in the

dark box. Since the ventilation of the box was not good, the conditions were not so favorable for the concentration of attention as in the other tests, but this distraction was the same for all subjects.

Since the size of the contact surface (2 mm. square) and the height of the fall (3 mm.) were kept constant throughout the entire series of tests, and the weight in the weight pan was the only factor varied, the results can be recorded for comparative purposes in terms of weight only. The determination of the threshold was rendered very difficult in some cases by a tendency to imagine stimulations as soon as the threshold was approached. Almost all of the subjects put a few imaginary sensations into the series. In a few the tendency was very marked. One subject — a man — counted a whole series of fifteen non-existent stimulations. The tendency was partially counteracted by telling the subject of his error. The point where seven or eight of the real stimulations were correctly counted, regardless of the extra ones inserted, was finally taken as the threshold.

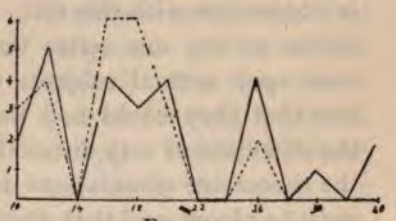

FIG. 13.

Threshold of impact.
Abscissas — weight in milligrams.
Ordinates — number of subjects.
- - - - women; —— men.

The curve for the threshold of impact (Fig. 13) shows a somewhat lower threshold in the women. In the region of very low thresholds the men and women are present in equal numbers, but the women are in excess in the middle lower ranges, and the men in the upper. The real difference is probably somewhat greater than

the curve represents, because the region used—the forearm—is more plentifully supplied with hairs in men than in women.

It is perhaps worth while to mention, in passing, a curious illusion experienced by several of the subjects in connection with this test. Although all the stimulations of any one series were given on exactly the same spot, several subjects volunteered the observation that they could feel the changes of position of the stimulations very distinctly. One subject said that the successive stimulations described a long oval from wrist to elbow, and that they differed in distinctness in different regions. There was no opportunity to examine further into this phenomenon.

2. *Threshold for pain on the right and left temples.*—The thresholds for pain on the temples were taken with a spring algometer registering 4,000 g. (57). The subject was required to lay his head on a thin padding on the table, with one temple up. A piece of chamois skin was placed under the metal disc of the algometer to prevent temperature sensations.

The subject was told that the pressure would be increased gradually and that he was expected to indicate the point at which he first began to feel pain. It was carefully explained to him that he was not to wait until the experience was decidedly painful, but was to indicate the point at which he could just begin to detect a feeling of pain in addition to a mere pressure sensation. The ease with which the discrimination was made differed very widely in different cases. Some subjects had a sudden sharp transition from mere pressure to pressure plus pain, which made it a simple matter to indicate the advent of pain. Others had a

very gradually increasing feeling of discomfort, almost from the beginning; to mark any point at which pain could be said to begin was extremely difficult—in fact, almost arbitrary. In such cases, there was no criterion except the final judgment of the subject himself. The test was repeated four times on each temple. The results which appear in the curves are averages of the four readings. Sometimes the right temple was taken first, and sometimes the left. A period of four or five minutes' rest was allowed between the two.

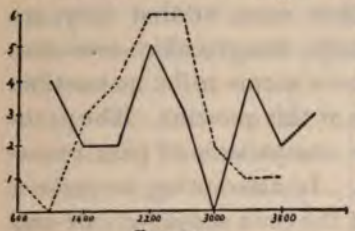

FIG. 14.

Algometer test. Left temple.[1]
Abscissas — pressure in grams.
Ordinates — number of subjects.
- - - - women; —— men.

The curves for the two temples (Figs. 14 and 15) are alike in general outline. In both cases the interpretation of the curve, as a whole, is lower pain thresholds for the women than for the men; but it is also true that both curves show more men than women with very low thresholds. In general, more women than men are found in the middle ranges, and more men than women at both extremes, but the preponderance of men is most marked in the region of high thresholds.

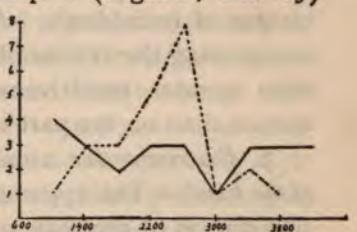

FIG. 15.

Algometer test. Right temple.[1]
Abscissas — pressure in grams.
Ordinates — number of subjects.
- - - - women; —— men.

[1]Only twenty-four women are represented in Figs. 14 and 15, because one woman was unwilling to submit to the algometer tests, fearing headache. This subject would probably belong to the lowest range.

The interpretation of the results offers the same apparently insurmountable difficulties as that of all similar experiments. Does it mean that women really feel pain more quickly than men, or that they are more apt to call a slightly disagreeable sensation painful than are men? There seems to be no possible criterion for a real decision of this question. The problem is not peculiar to the comparison of pain sensations of men and women. In attempting to make a quantitative comparison of the pain sensations of any two individuals the standard is absolutely subjective, and must be accepted as such. It must in consequence be admitted that quantitative measurements of pain are less capable of control and consequently less reliable than most quantitative measurements of sensation processes. But this fact does not justify the assumption of a difference in pain standard on the part of different classes of individuals. As far as we are capable of interpreting the results obtained, they indicate somewhat greater sensitiveness to pain on the part of women than on the part of men.

3. *Discriminative sensibility for pressure on the palm of the hand.*—The apparatus used for testing the discrimination of pressure was a series of little wooden bottles weighted with shot. The series consisted of twenty-one bottles beginning with 80 g. and ending with 100 g. The uneducated hand, in most cases the left, was used for the test. The hand was supported on padding as comfortably as possible and was perfectly relaxed. It had to be placed in such a position that it offered a flat space large enough to allow of setting the bottles upright. A small cork disc was placed on the hand first, to give a smooth surface of

contact and insure placing the bottles in approximately the same spot each time.

The two weights to be compared were placed successively on the same spot, and the subject, whose eyes were closed, was asked to say which of the two was heavier. The 100-g. weight was used as the standard. The subject was not told anything about a standard. He was merely asked to make the comparison between the two weights given him, and did not know that one of them each time was the 100-g. weight. The standard was put on sometimes first, and sometimes second, to avoid any constant errors of order. The series of tests began with the large differences, usually 80 and 100. If these were judged correctly every time, a smaller difference was tried. The number of tests with each pair of weights was increased as the limit of discrimination was approached. The point finally fixed upon as the discriminative sensibility was the point at which three-fourths of twelve or sixteen judgments were correct.

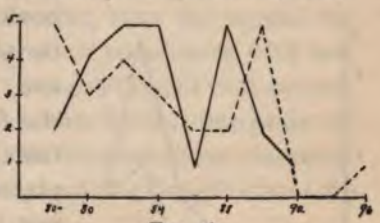

FIG. 16.

Discriminative sensibility for pressure. Standard, 100 g.
Abscissas — weight just discriminable from the standard.
Ordinates — number of subjects.
- - - - women; —— men.

The results (Fig. 16) show no marked difference between the men and the women. The women are a little more numerous in both the upper and the lower ranges, but the average is about the same for both sexes.

4. *Discriminative sensibility for lifted weights.*—The apparatus used for testing the discriminative sensi-

bility for lifted weights was the series of wooden bottles used for the previous test. The subject was required to lift the bottles with the thumb and forefinger of the uneducated hand—usually the left. He sat with his eyes closed, and his hand held in such a position that the bottle could be placed between the thumb and forefinger. After lifting the first one, he set it on the table, and it was at once replaced by the second. For the rest, the experiment was carried out in the same way as the preceding one.

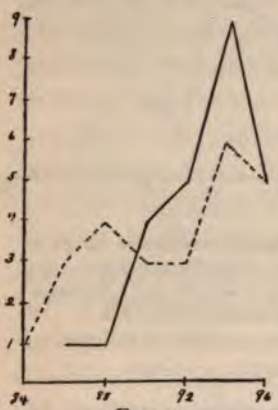

FIG. 17.

Discriminative sensibility for lifted weights. Standard 100 g.

Abscissas—weight just discriminable from the standard.

Ordinates—number of subjects.

- - - women; —— men.

The results represented in Fig. 17 show a much finer discrimination on the part of the men. There is a much larger proportion of men than of women who can discriminate a difference of 4 to 10 g., while the reverse is true in the range of differences greater than 10 g. Since the discrimination of lifted weights involves principally the joint sensations, this test is closely allied with the motor tests. The finer discrimination of the men for weights is in accord with their better developed motor ability in general.

B. SPACE SENSATIONS.

1. *Discrimination of two points crosswise and lengthwise on the volar side of the forearm.*—Jastrow's æsthesiometer was the instrument employed for testing the

discrimination of two points on the skin. The instrument allowed the distance between the two points to be varied from 1 mm. to 100 mm. The region used was the middle of the volar side of the right forearm. The arm was supported on a padding in a comfortable position. The subject was told that he would be touched in the region described, sometimes with one point and sometimes with two, and that all that was required of him was to tell whether he felt one point or two. The measurement of the discrimination crosswise of the arm was taken first, and the lengthwise test followed on another day.

In making the test, stimulations with one point were frequently inserted in the series as a control. Often the judgments seemed to be pure guesses when the difference was really below the discriminative sensibility of the subject. In these cases the distance was increased until a reliable judgment could be made. In a few instances a genuine illusion seemed to be involved, which caused the judgments to remain difficult and variable through a large range of differences. All that could be done was to fix an approximate point after a long series of experiments. Frequently the guessing process would be stopped, or at least much reduced by telling the subject that he was calling one point two. The series of tests was begun with a difference a little below the average discriminative sensibility and was increased or decreased as the case demanded, until the least difference was found at which three-fourths of the judgments of two points out of twelve or sixteen were correct.

The women proved to have a somewhat finer discrimination in the crosswise direction (Fig. 18) and a decidedly finer discrimination in the lengthwise direc-

tion (Fig. 19). In the former case the two curves occupy the same range. The difference is shown by the preponderance of women with a small discriminative sensibility and the preponderance of men with a large discriminative sensibility. In the latter case (the lengthwise discrimination the difference is so great that the two curves occupy a different range; the women's curve from 20 to 65 mm., and the men's curve from 35 to 75 mm.

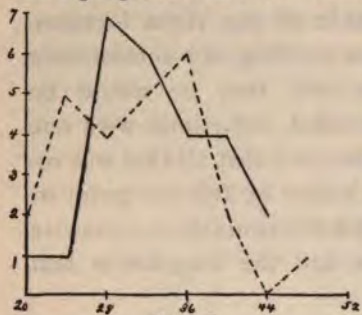

FIG. 18.

Æsthesiometer test. Crosswise.
Abscissas — millimeters between the two points.
Ordinates — number of subjects.
- - - - women; —— men.

There are two factors which doubtless combine to decrease the apparent difference in the discriminative sensibility of the two sexes in the tests made across the arm. The first is that the curve of the arm makes it very difficult to put the instrument down crosswise in such a way that the two points strike simultaneously and exert the same pressure. Inequalities of time and pressure are therefore much more likely to assist the judgment in the crosswise test than in the lengthwise. The second factor is that the structure of the arm is much more differentiated crosswise than it is

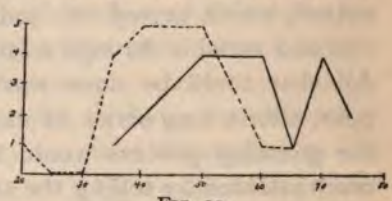

FIG. 19.

Æsthesiometer test. Lengthwise.
Abscissas — millimeters between the two points.
Ordinates — number of subjects.
- - - - women; —— men.

lengthwise. If one point rests on one tendon and the other on another it is easy to distinguish two points by an indirect judgment, because the difference between the two tendons is already known. The judgment ceases to be a pure skin discrimination and becomes a complex judgment based on other sorts of experience. In the lengthwise test, on the other hand, the two points fall upon a homogeneous substructure, a single muscle or tendon, and the discrimination is much more nearly a pure skin judgment.

2. *Discrimination of areas on the volar side of the forearm.*—The apparatus used for determining the discriminative sensibility of the skin for area was a series of five cork blocks about 3 mm. thick, varying in size from 10 mm. square to 20 mm. square. A preliminary test was made with the blocks all weighted to the same amount—20 g. It was found that in this case the smallest block felt so much heavier than the largest that the difference in pressure interfered seriously with the judgment of size. Either the smaller block was called larger, because the factor of pressure was not clearly separated from that of size, or the subject reported himself unable to make any reliable size judgment because of the disturbing difference in weight. With the hope of remedying this evil the blocks were then weighted proportionately to their area, so that equal amounts of pressure should be exerted on equal skin areas in all stimulations. This attempt was only partly successful. The smallest block now felt lighter than the largest. The series of tests was nevertheless carried out with the latter blocks, because the difference of pressure was much smaller with them than with the former; but the

results cannot be regarded as entirely reliable. Until the relation of pressure and area in judgments of area on the skin has been made the object of special investigation, and series of areas weighted to produce equal sensations of pressure have been determined, no thoroughly reliable results in this field can be obtained. This series of tests, as well as all previous investigation, suffers from this defect.

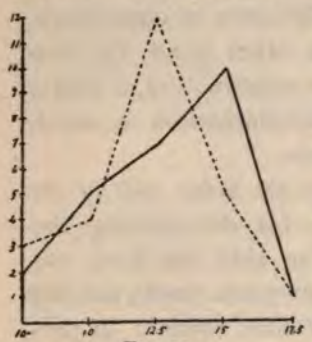

FIG. 20.

Discriminative sensibility for area. Standard, a block 20 mm. square, weighing 20 g.

Abscissas — size of the block just discriminable from the standard.

Ordinates — number of subjects.

- - - - women; —— men.

The area of skin employed for the discrimination of size was the same as that used for the touch and space thresholds — the middle of the volar side of the right forearm. This experiment, like that for the touch threshold, was made during the time required for the fatigue of the retina for the threshold of light (see p. 76). The method was that used for all the experiments in discriminative sensibility; two areas were applied successively, and the subject was asked to report each time which of the two felt larger. The series began with the largest difference and worked down to the smallest difference, regarding which three-fourths of the judgments out of twelve or sixteen were correct.

The curves presenting the results of the test (Fig. 20) show a somewhat better discrimination for area on the part of the men. Their curve culminates at 15, and that of the women at 12.5. The outer limits of the two curves are the same.

C. TEMPERATURE SENSATIONS.

The only aspect of temperature sensation experimented upon was that of the discriminative sensibility. It was tested with three different standards: one near the physiological zero, 30° C.; one approaching the pain threshold for cold, 5° C.; and one in the region of the pain threshold for heat, 45° C.

The method of giving the stimulus was the same in all three cases, viz., immersing the first two fingers of the right hand to the second joint in water. To facilitate preserving a constant temperature, a large mass of water was used. The apparatus consisted of two large zinc basins, eighteen inches long, ten inches wide, and six inches deep. They were filled to within an inch of the top. The basins were covered with asbestos jackets to prevent changes of temperature. Asbestos lids with openings for the thermometer and for the immersion of the fingers covered the basins. The thermometers, reading tenths of a degree, were hung very close to the place where the fingers were immersed, to insure the recording of the temperature of the water actually used in the stimulation. Each basin was set on a tripod, and supplied with a Bunsen burner for changing the temperature. For the cold stimulation, ice was used. The temperature changed very slowly, and by leaving a low flame, experimentally determined, under the basin, it was possible to keep the temperature constant through considerable periods of time. The changes of temperature required some time and patience. They could be produced rapidly enough, but it was difficult to bring them to a standstill at exactly the point required for the test. To economize time, the intervals required for chang-

ing the temperature were employed by the subjects in writing their answers to the questions on general information (see chap. vii, sec. D), and in sorting the worsteds for the test on color-blindness (see chap. vi, sec. D). It required from half an hour to an hour to determine the discriminative sensibility with each standard.

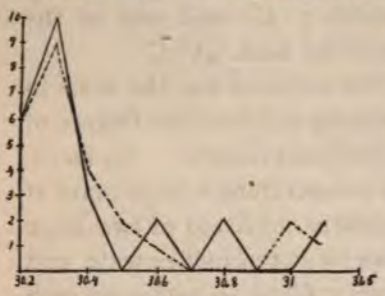

FIG. 21.

Discriminative sensibility for temperature. At the physiological zero. Standard, 30° C.

Abscissas — temperature just discriminable from standard.

Ordinates — number of subjects.

- - - - women; —— men.

The method of making the discrimination was the same as that used in the other tests. The subject was told to put his fingers first into one basin and then into the other, and tell which felt the warmer. The fingers were dried after each discrimination, and time was allowed for the effects of the extreme stimuli to disappear. It was not possible to make so many judgments for each stimulus difference as in the case of the other skin discriminations, partly because the effects of the extreme stimuli are so lasting that only a few tests can be made without long rest intervals, and partly because it was impossible to hold the temperature absolutely constant for many tests at a time. Consequently, three correct judgments out of four, or at most four out of six, were regarded as decisive. If further tests threw doubt on the accuracy of any determination, the same stimulus difference was tried a second time.

Since the order in which the stimuli are given is a very important factor in temperature discriminations, great care was taken to see that an equal number of judgments was made in each order. The summation of stimuli which tends to make the second stimulus feel more intense than the first is more marked in temperature than in any other sense. The difference required to make the more intense stimulus feel more intense when it was given first was frequently very large in the cold and hot ranges, whereas when it came second, a very slight difference was sufficient. In fact, when the two were of the same temperature, or the second a little less intense, the second was judged more intense. In the form of temperature test in which the subject is allowed to put his fingers back and forth from one basin to the other, much smaller absolute differences can be discriminated than those reported in this test, but the judgment made is not a simple sense discrimination comparable with those made in the other senses. For example, if a discrimination with two very cold temperatures is being made, and the subject is allowed to have each stimulation but once for each judgment, he will say that the second one is colder each time, but that the difference in temperature is much greater in one order than in the other; and that he therefore believes that the basin which when second is a colder

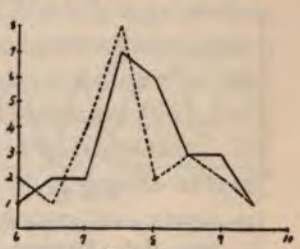

FIG. 22.

Discriminative sensibility for temperature. Cold. Standard, 5° C.

Abscissas—temperature just discriminable from standard.

Ordinates—number of subjects.

- - - - women; —— men.

second, is *really* colder. The same process in less conscious form is what takes place when the subject is allowed to change back and forth from one basin to the other. Each stimulus, as he gets it, feels colder than the previous one, but the difference is much more intense when he goes from the really less intense to the more intense than when he goes in the opposite direction. He reaches a correct judgment as to which is colder, but the judgment is not a simple temperature discrimination; it is an indirect judgment. The absolute values obtained for temperature discrimination are therefore largely dependent on the method. The results differ with the method far more in the extreme temperatures than in those near the physiological zero. The present results represent simple temperature discriminations, and show correspondingly large values for the discriminative sensibility in extreme temperatures.

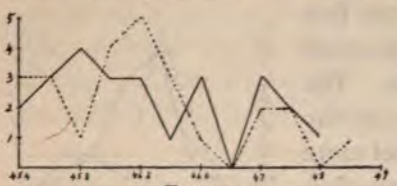

FIG. 23.

Discriminative sensibility for temperature. Hot. Standard, 45° C.
Abscissas—temperature just discriminable from standard.
Ordinates—number of subjects.
- - - - women; —— men.

The curves for the temperature tests (Figs. 21–23) show very slight variation in the sensibility of the two sexes. At the physiological zero no distinction can be made. In the two extreme temperatures the women have a slight advantage. They are grouped somewhat more toward the region of fine discriminations, but the difference is scarcely large enough to be regarded as significant.

SUMMARY OF OTHER EXPERIMENTAL WORK ON SKIN AND MUSCLE SENSES.

There are no results directly comparable with the test on the threshold for impact. The so-called measure of the fineness of touch in the Italian investigations (Lombroso, Ottolenghi, Di Mattei) is an æsthesiometer test. The experiments on general sensibility, however, are often considered to be a measure of the delicacy of tactile sensations. Ottolenghi (66) calls general sensibility a sort of contact sensation. Its measure is the least amount of a faradic current which can be perceived. Lombroso (51, chap. iii) reports that women have a less keen general sensibility than men, while Dehn (20) experimenting with a small number of individuals, and Ottolenghi (66) from returns on eight hundred women and six hundred men, agree that women have a keener general sensibility than men. Di Mattei (21) corroborates this result for children of from four to twelve years. Griffin (31) has shown that sensitiveness to electrical stimulation and sensitiveness to pressure stimulation do not necessarily vary together. It is therefore impossible to argue directly from keener general sensibility to more acute touch.

There is a much greater mass of material for the comparison of men and women with reference to sensitiveness to pain. Two methods of inducing pain have been employed; one by electrical stimulation and the other by pressure. Lombroso (50, 51), Ottolenghi (66), Di Mattei (21), and Dehn (20) used the former method. The three Italians, the first two working with adults, and the last with children of from four to twelve years, all find the female less sensitive to pain

through electrical stimulation than the male, while Dehn finds women more sensitive than men. The former result is based on a far greater mass of results than the latter.

The experiments made by the second method, pain through pressure, all agree with the present series of tests in showing a lower threshold for women than for men. Wissler (82) and MacDonald (54) experimented on adults, Carman (16) on children, and Swift (78) on both adults and children. The relation holds for all ages.

There is but one comparative test on passive pressure, that made by Dehn (20). He used an error method instead of a gradation method, but his results agree with ours in showing no difference between the sexes in this respect.

The ability to discriminate lifted weights was found by Gilbert (quoted by MacDonald, 55, p. 1107) to be greater in boys than in girls between the ages of thirteen and seventeen, a result which corroborates ours. Wolfe (83) in experimenting on the effects of size on judgments of lifted weights, finds women much more subject to illusion than men. Gilbert (30) finds the same difference between boys and girls. Both are inclined to explain the fact by the greater suggestibility of the female. If it is true, however, that the actual ability to discriminate lifted weights is less in women than in men, this may explain in part the fact that they are more subject to the size-weight illusion than men.

Other forms of test on the perception of weight do not agree with the discriminative tests in showing less accuracy on the part of women. Wissler (82)

reports a test in which the subject was required to lift against a spring to 1 kg. as a standard, and then attempt to lift the same amount several times from memory. He found no difference in the ability of men and women to do this. Jastrow (38) required his subjects to estimate a pound and an ounce in shot with no guide or standard. He found women more accurate than men. The results suggest the generalization that men excel women in the direct discrimination of lifted weights, but are equaled or excelled by women in tests where the memory of a given weight is involved; but no stress can be laid on such a statement until more data are available.

There are several comparative tests at hand on two-point discriminations. Galton (27), Dehn (20), Lombroso (51, chap. iii, 50) and the Columbia University tests (82) dealt with adults. Galton measured about 1,200 men and women on the nape of the neck, using a method like that of the present test. His results are in accord with ours in showing a finer discrimination on the part of the women. Dehn's test and those on Columbia students failed to show any difference of sex in this respect. The method used is probably a sufficient explanation for the fact in both cases. The æsthesiometer points were kept a fixed distance apart, and the right and wrong answers on a small number of stimulations were recorded. The results thus yielded are too meager to give any reliable measurement. Lombroso, experimenting on 100 normal men and 100 normal women, finds women less sensitive than men. His subjects were of varying ages and social conditions, but he states that the general relation holds also for men and women of the educated class. He

does not describe his method. The fact that in several other respects his results are contradictory to those of other observers, makes one hesitate to lay much stress on this discrepancy. There are two æsthesiometer tests on children, that by MacDonald (55, p. 1005) made on the palmar surface of the wrist, and that by Di Mattei (21) made on the index finger. MacDonald's method, and presumably Di Mattei's, though he is less explicit, were analogous to ours. Both sets of results agree with ours in showing the female to have a finer discrimination of two points than the male.

There are no previous data known to the author on the comparative ability of the sexes to discriminate area on the skin. One would expect to find that the class with the finer two-point discrimination was also the one with the greater ability to discriminate area on the skin, but this does not hold in the present case. Since the discrimination of area is a complicated judgment involving several factors, it is by no means sure that it need be correlated with a two-point discrimination. If the two results are contradictory, doubt should be thrown on the test in the discrimination of area rather than on the æsthesiometer test, since the conditions of the former were much less satisfactory than those of the latter.

There are two tests on temperature discrimination in which a comparison of the sexes has been made; one by Dehn (20) on adults, and one by MacDonald (55, p. 1005) on school children. The method in both cases differed from that employed in the present tests. It consisted in stimulation of the skin by metal surfaces of known temperature. Dehn used successive stimu-

lations and MacDonald simultaneous stimulations. Dehn's temperatures were near the physiological zero. MacDonald gives no standard, but one of the stimuli was certainly above the physiological zero, since the test is called a discrimination of heat. Dehn finds women more sensitive than men. MacDonald finds boys, on the whole, slightly more sensitive than girls. The present tests show no difference of sex. It seems safe to conclude that sexual differences in ability to discriminate temperatures are very insignificant, if they exist at all.

GENERAL SUMMARY OF EXPERIMENTS ON SKIN AND MUSCLE SENSES.

The general outcome of the experimentation on the sensations mediated by the skin is to show that women have somewhat keener senses than men. This statement does not hold for all forms of sensation. The greater sensibility of women is marked in the two-point discrimination, in general sensibility, and in sensitiveness to pain through pressure; and is slight in delicacy of touch. In passive-pressure discrimination and in temperature there is no difference. In pain through electrical stimulation, the discrimination of lifted weights, and possibly, in the discrimination of area on the skin, men are more sensitive.

CHAPTER IV.

TASTE AND SMELL.

THE experiments in taste and smell dealt with the following subjects:

A. Taste.
   1. Threshold of presence[1] for sweet, salt, sour, and bitter.
   2. Threshold of recognition[1] for sweet, salt, sour, and bitter.
   3. Discriminative sensibility at T_2.
   4. Discriminative sensibility for strong tastes (viz., those of series B of Table VIII).

B. Smell.
   1. Threshold of presence for cloves and violet.
   2. Threshold of recognition for cloves and violet.
   3. Discriminative sensibility at T_2.
   4. Discriminative sensibility for strong odors (viz., those of series B of Table IX).

A. TASTE.

The substances used for the four tastes were saccharin, chemically pure salt, sulphuric acid, and sulphate of quinine. Two series of solutions in distilled water were prepared from each substance. Series A began below the normal threshold of presence and extended above the average threshold of recognition. Series B consisted of solutions which were all strong to the normal taste. The limits of the series, and the gradations necessary in each one were determined experimentally. The bottles containing the solutions

[1] The term "threshold of presence" is sometimes represented in this chapter by the symbol T_1, and the term "threshold of recognition" by the symbol T_2.

were all alike in appearance. The series of solutions, in percentages, are given in Table VIII.

No attempt was made to control the temperature of the solutions any more closely than the temperature of the room.

TABLE VIII.

Series of solutions used in testing taste.

	Sweet.		Salt.		Sour.		Bitter.	
	A	B	A	B	A	B	A	B
1	.0005%	.025%	.01%	2. %	.001%	.017%	.00004%	.001 %
2	.00075	.027	.04	2.05	.003	.018	.00008	.0012
3	.001	.029	.08	2. 1	.005	.019	.0001	.0014
4	.0015	.031	.1	2.15	.006	.02	.0002	.0016
5	.002	.033	.11	2. 2	.007	.021	.0003	.0018
6	.0025	.035	.12	2. 3	.008	.022	.0004	.002
7	.003	.037	.13	2. 4	.009	.023	.0005	.0022
8	.0035	.039	.14	2. 5	.01	....	.0006	.0024
9	.004	....	.15	2. 6	.011	....	.0007	.0026
10	.0045	....	.16	....	.012	....	.0008	.....
11	.005	....	.18	....	.013	....	.....	.....
12	.....	....	.2	....	....	....	.....	.....
13	.....	....	.22	....	....	....	.....	.....

1 and 2. *Thresholds of presence and of recognition.* —The two thresholds of presence and of recognition were obtained by the same method and in the same series of experiments. The subject was seated with his back to the table containing the bottles, in order that he might not see which bottles in a series were taken. He was given a cup containing distilled water and was told that it was distilled water and would be his standard of comparison. The distilled water was not tasteless to most subjects, but tasted differently to different individuals. Sometimes it seemed sweet, sometimes bitter, and rarely salty or sour. In spite of the subjective tastes assigned to the distilled water it

seemed necessary to use it as a basis for the solutions. It would have been extremely difficult, if not impossible, to find any one solution which would be pronounced tasteless by all subjects. Since the distilled water was constantly before the subject as a standard of comparison, the necessity for having a solution to start with which was subjectively tasteless was lessened. All the subject was required to tell about the solutions given him was whether or not they were the same as the distilled water, and if not, how they differed.

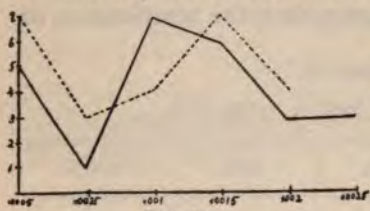

FIG. 24.

Taste. T_1 for sweet.
Abscissas — percentage of the solutions.
Ordinates — number of subjects.
- - - - women; —— men.

Since taste is a sense which, like smell, is peculiarly subject to illusions at the threshold, the subject was given two bottles at each test, one of which contained distilled water, and the other a weak solution. When a difference from the distilled water of the cup was reported, the subject was asked in which bottle he noticed it. If it was an illusion, it was quite as likely to be referred to the distilled water bottle as to the solution. Often the subject said that both bottles

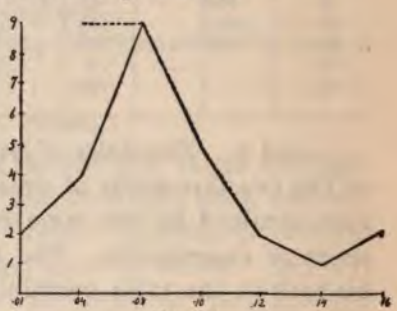

FIG. 25.

Taste. T_1 for salt.
Abscissas — percentage of the solutions.
Ordinates — number of subjects.
- - - - women; —— men.

were different from the distilled water. If they seemed equally different, it was again counted as an illusion. If the bottle containing the solution was reported more different from the standard than the bottle containing distilled water, the discrimination was regarded as genuine, but a threshold was determined only after three correct judgments out of four.

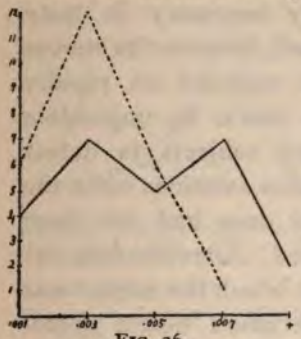

FIG. 26.

Taste. T_1 for sour.
Abscissas — percentage of the solutions.
Ordinates — number of subjects.
- - - - women; —— men.

The order of procedure was as follows: The subject was provided with a cup of distilled water and a teaspoon. A jar was placed beside him, and he was told not to swallow the solution unless he wished. Two bottles just alike in appearance were placed before him, and he was directed to taste the distilled water in the cup first, and then taste half a teaspoonful of the liquid in each bottle. He was told that he must make the solution touch all parts of the tongue in tasting, since not all parts were equally sensitive. After tasting each solution once, he was required to tell which one, if either, differed from the distilled water of the cup. Both bottles were then removed, and two more given him.

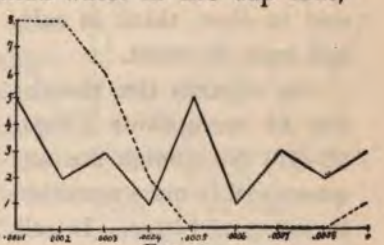

FIG. 27.

Taste. T_1 for bitter.
Abscissas—percentage of the solutions.
Ordinates — number of subjects.
- - - - women; —— men.

The tests always began with the weakest solutions, and worked up to the place where the discrimination from distilled water could be made. This procedure is particularly necessary in taste and smell, because the nerves become fatigued so rapidly that it would be impossible for most subjects to detect the weaker solutions when the stronger ones had just been perceived. After reaching the point at which the subject was sure he could detect something in the solution (T_1), the same process was continued until he was able to identify the taste (T_2).

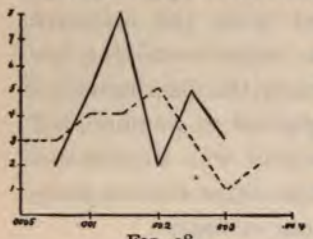

FIG. 28.

Taste. T_2 for sweet.
Abscissas — percentage of the solutions.
Ordinates — number of subjects.
- - - - women; —— men.

The curves for the threshold of presence (Figs. 24–27) show a lower threshold for the women in all four tastes. The difference is most marked in bitter, second in sour, third in salt, and least in sweet.

As regards the threshold of recognition (Figs. 28–31) the women are unquestionably more sensitive to sour and bitter. In salt the women's curve is slightly better. It has more entries in the region of very low thresholds, and no cases which fall beyond the limits of the series. The curve for sweet averages about the same for both sexes. Both the best records and the worst are those of women.

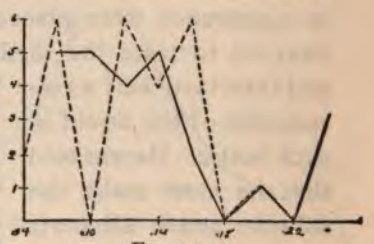

FIG. 29.

Taste. T_2 for salt.
Abscissas — percentage of the solutions.
Ordinates — number of subjects.
- - - - women; —— men.

3 and 4. *Discriminative sensibility.*—The discriminative sensibility for taste was tested with two standards. The first was the solution marking each subject's threshold of recognition, the second was identical for all subjects, viz., the first solution in series B of Table VIII. The subject sat as for the previous test. Two bottles were set before him, and he was required to judge which of the two solutions was the stronger. The mouth was rinsed with distilled water after each discrimination.

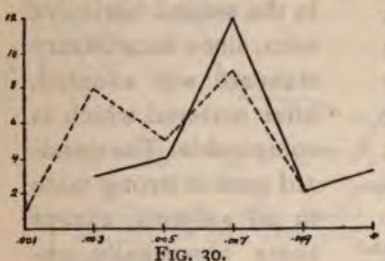

FIG. 30.

Taste. T_2 for sour.[1]
Abscissas — percentage of the solutions.
Ordinates — number of subjects.
- - - - women; —— men.

Since the standard stimulus for the first discrimination was the solution marking each subject's threshold of recognition, a comparison of results is difficult. The thresholds of recognition were scattered over a wide range, and there proved to be so small a number of men and women having the same standard that there are not sufficient data for a comparison. What few records are comparable show no marked differences, but they are too few in number to be of any significance. A comparison by percentages was

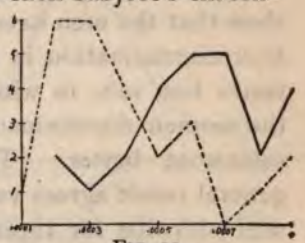

FIG. 31.

Taste. T_2 for bitter.
Abscissas — percentage of the solutions.
Ordinates — number of subjects.
- - - - women; —— men.

[1] Only twenty-four men are represented in this diagram. One record was not taken.

not feasible because the gradations of the taste series were not sufficiently fine to warrant it.

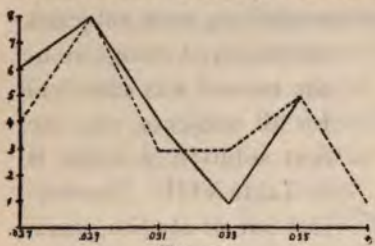

FIG. 32.

Taste discrimination. Sweet. Standard, .025 per cent. solution of saccharin.[1]

Abscissas — percentage of the solutions just discriminable from the standard.

Ordinates — number of subjects.

---- women; —— men.

The discriminations in the second series of tests, since an arbitrary standard was adopted, offer material which is comparable. The standard gave a strong taste to all subjects, except those abnormally obtuse. The method of making the discrimination was the same as that described for the previous series.

The results of the tests on the discrimination of strong tastes (Figs. 32–35) show that the men have a finer discrimination in all tastes but salt, in which the women discriminated somewhat better. The general result agrees very well with that for thresholds. The lower the threshold for a given sense the coarser the discrimination in very strong stimuli. The same solution in the so-called strong series tastes much stronger to a subject

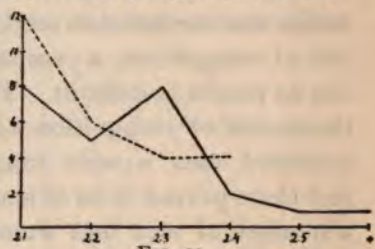

FIG. 33.

Taste discrimination. Salt. Standard, 2 per cent. solution.

Abscissas — percentage of the solutions just discriminable from the standard.

Ordinates — number of subjects.

---- women; —— men.

[1] Only twenty-four of each sex are represented in this diagram. Two records were not taken.

with a low threshold than to one with a high threshold, and the fineness of discrimination is correspondingly reduced. Whether or not this cause is sufficient to account for all the difference in discrimination, it is impossible to say. It might be that if we could obtain a subjectively identical standard for all subjects, we should still find the men having a finer absolute discrimination. However that may be, the fact remains that, given an arbitrary objective standard in the region of strong tastes, the men have a finer discrimination than the women.

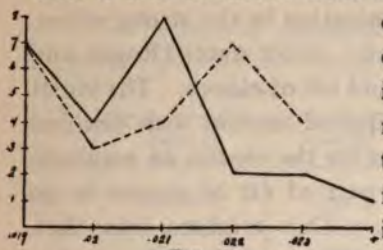

FIG. 34.

Taste discrimination. Sour. Standard, .017 per cent. solution of sulphuric acid.[1]

Abscissas — percentage of the solutions just discriminable from the standard.

Ordinates — number of subjects.

---- women; —— men.

B. SMELL.

The tests for smell were analogous to those for taste as to apparatus and method. They were made with two series of solutions, one designed to determine the two thresh-

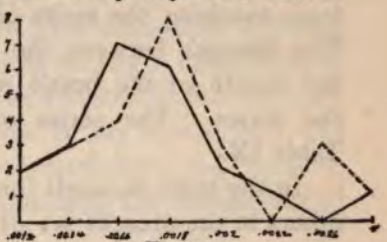

FIG. 35.

Taste discrimination. Bitter. Standard, .001 per cent. solution of quinine.[2]

Abscissas — percentage of the solution just discriminable from the standard.

Ordinates — number of subjects.

---- women; —— men.

[1] Only twenty-four men are represented in this diagram. One man could not distinguish sour.

[2] Only twenty-four women and twenty-two men are represented in this diagram. One woman and two men had thresholds for bitter which were above the standard. One man could not distinguish bitter at all.

olds of presence and of recognition, and the other to test the fineness of discrimination in the strong odors. Two substances were used: violet water (Roget and Gallet *violette de Parme*), and oil of cloves. The violet was simply diluted the required amount with distilled water. As a basal mixture for the cloves, an emulsion was made by shaking 1 part of oil of cloves in 99 parts of distilled water. This mixture was then diluted to form the series, being shaken thoroughly at each step. The odors were both so persistent that great care was necessary in preparing the weaker solutions. The utensils which had been used for stronger solutions had to be thoroughly cleansed with alcohol and distilled water before being used to make the weaker ones. The solutions were placed in glass-stoppered bottles all alike, being prevented from touching the necks of the bottles when put in. The distance between the surface of the liquid and the mouth of the bottle was made constant for all the series. The series of solutions are given in Table IX.

In the tests on smell (unlike those on taste and all others in the present set of experiments where judgment between two stimuli formed the *modus operandi*) the subject was allowed to have as many stimulations as he wished from each of the two bottles given him, in the determination both of the thresholds, and of the discriminative sensibility. The reason for this departure in the case of smell is that it is the only sense in which the contact between external stimulus and nerve-ending is produced so indirectly. The actual stimulation of the nerve-ending depends upon

TABLE IX.

Series of solutions used in testing smell.

	Cloves.		Violet.	
	Series A.	Series B.	Series A.	Series B.
1	.000001%	.001 %	.0000001%	1. %
2	.000005	.0012	.000001	1.2
3	.00001	.0014	.00001	1.4
4	.00005	.0016	.00005	1.6
5	.0001	.0018	.0001	1.8
6	.0002	.002	.0005	2.
7	.0003	.003	.001	2.2
8	.0004	.004	.01	2.4
9	.0006	.....	.....	....
10	.0008	.....	.....	....

the nature of the inhalation. Two successive smellings of the same bottle may give sensations differing widely in intensity, depending on slight differences in inhalation. The subject was directed to use the same nostril for both stimulations in any comparison, and was allowed to go back and forth from one bottle to the other, in the hope of equalizing the inequalities of the single stimulations.

1 and 2. *Thresholds of presence and of recognition.*— The determination of the smell thresholds was made by a method like that used for the taste thresholds, but differing in two respects. The first modification was that common to all the smell tests stated above; the second was that the subject was not provided with a bottle of distilled water which he knew to be such, corresponding to his standard of reference in the experiments on taste. This did not seem to be neces-

sary, because distilled water showed no tendency to stimulate the nerves of smell in any definite direction, as it stimulated those of taste.

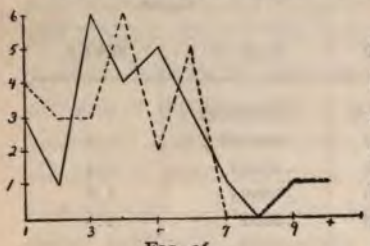

FIG. 36.

Smell. T_1 for cloves.
Abscissas — number of the solutions (see Table IX).
Ordinates — number of subjects.
- - - - women ; —— men.

For determining the threshold of presence two bottles were given to the subject, one of which each time contained distilled water. He then reported whether or not he could distinguish any odor in either bottle. The point at which he could select the right bottle three times out of four was taken as the threshold. To avoid the fatigue effects which are so marked in the sense of smell, the series began with the weakest solutions and advanced to the stronger.

The curves for the threshold of presence (Figs. 36 and 37) show a lower threshold for the women, though the difference is slight. It is indicated chiefly by the greater number of women in the regions of extremely low thresholds for both sexes.

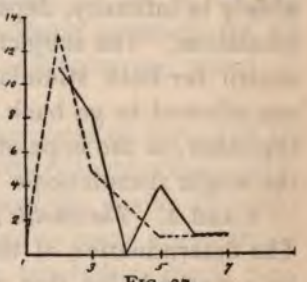

FIG. 37.

Smell. T_1 for violet.
Abscissas — number of the solutions (see Table IX).
Ordinates — number of subjects.
- - - - women; —— men.

In the tests for determining the threshold of recognition the subjects were not required to name the substance used as stimulus, but simply to name the class to which the odor belonged.

"Spicy" was called a recognition for cloves, and "perfume" for violet The effects of practice would have been a disturbing factor if a more definite recognition had been required, but the general classes of spice and perfume are familiar to all.

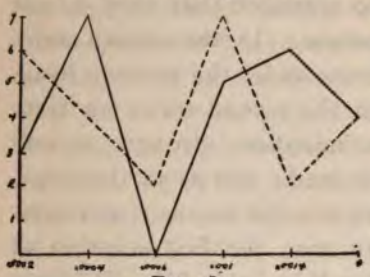

FIG. 38.

Smell. T_2 for cloves.
Abscissas — percentage of the solutions.
Ordinates — number of subjects.
- - - - women ; —— men.

The threshold of recognition, like that of presence, is a little better in the women than in the men (Figs. 38 and 39). The women are somewhat more numerous in the region of low thresholds, and the men in the region of high. Again the difference is slight. The objection might be made that the two odors selected, cloves and violet water, are more likely to be familiar to women than to men ; but since the recognition required was merely of spice or perfume, it does not seem probable that the greater familiarity of the women with the odors could have been a factor in the result. The subject was told that he need not name the substance, but merely describe it as best he could, or name the class of substances to which it belonged.

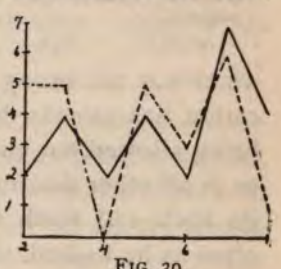

FIG. 39.

Smell. T_2 for violet.
Abscissas — percentage of the solutions.
Ordinates — number of subjects.
- - - - women ; —— men.

3 and 4. *Discriminative sensibility.*—Like the corre-

sponding series for taste, the first series of tests on discrimination of odors was made at the threshold of recognition; and as in the case of taste, so in that of smell the standards are so scattered that they do not afford material for comparison. In the second series of tests under the present head, as in the second series on taste discrimination, stronger stimuli were used; and as in that case, so in this the standard was arbitrary, viz., the first solution of series B in Table IX. This second series of tests yielded results capable of comparison.

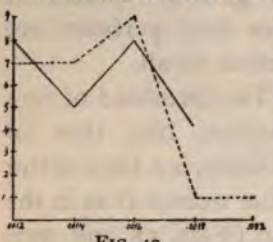

FIG. 40.

Smell discrimination. Cloves. Standard, .001 per cent. solution of oil of cloves.

Abscissas — percentage of the solutions just discriminable from the standard.

Ordinates — number of subjects.

- - - - women; —— men.

The method of making the discrimination was the same as that usually employed. Two bottles, one of which was the standard, were given to the subject, and he was asked to decide which was the stronger of the two. The only modification has already been stated, viz., that instead of being allowed but one stimulation from each stimulus, as in all other discrimination tests, he was allowed to go back and forth from one bottle to the other as often as he wished. A period of several minutes was allowed between stimulations for the recovery of the nerve.

The results (Figs. 40 and 41) show a somewhat better discrimination in cloves on the part of the women, while in violet the difference is too slight to be of any significance; the curves are almost coincident. The difference is probably partly due to the fact that the

solution of cloves was much less intense than the violet. Many of the thresholds of recognition for cloves fell within the higher series (see Fig. 38), while those for violet were all far below the series. The reason for the difference between the two series is that cloves increase faster in intensity of odor with increased strength of solution than violet. A 1 per cent. solution of cloves is entirely too strong to serve as the standard for a series, while a 1 per cent. solution of violet is usable. In attempting to tone down the cloves to a point where the intensity of the after image was not sufficient to interfere seriously with discrimination, the standard was made far less in absolute intensity than that of the violet series. The fact that, using these series, we find the women's discrimination better than the men's in cloves, and about the same in violet, accords with the lower thresholds of the women in both smells. We find, as we should expect, the class having the lower thresholds better in the discrimination of odors of medium intensity, but not in the discrimination of very strong odors.

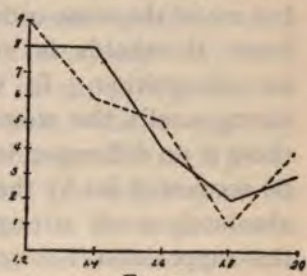

FIG. 41.

Smell discrimination. Violet. Standard, 1 per cent. solution of Roget and Gallet *violette de Parme*.

Abscissas—percentage of the solutions just discriminable from the standard.

Ordinates—number of subjects.

- - - - women; —— men.

The results of the tests on taste and smell may be summarized as follows: In taste the women have lower thresholds than the men both for presence and for recognition The difference between the sexes is most marked in sour and bitter, much less so

in salt, and very slight in sweet. The discriminative sensibility for strong tastes is finer in the men in all tastes except salt, in which it is slightly better in the women. The differences between the men and the women in smell are less than those of taste, but are of the same order. The women have slightly lower thresholds in smell, both for presence and for recognition. In discriminative sensibility for strong smells, the women are better in cloves, while there is no difference in violet. The difference may be accounted for by the fact that the violet series was absolutely much stronger than the clove series. If this supposition is correct, the results for smell are in accord with those for taste; the women have lower thresholds, but their discriminative sensibility in the strong series is as coarse or coarser than that of the men.

SUMMARY OF OTHER EXPERIMENTAL WORK ON TASTE AND SMELL.

Experiments on the comparative keenness of the sense of taste in men and women have been performed by Bailey and Nichols (6), Bailey (7), Lombroso (51, chap. iii), Roncoroni (72), Ottolenghi (63), Dehn (20), and Di Mattei (21). In no case has the method been so exact as that employed in the tests here reported. Bailey and Nichols prepared series of each of five tastes—sweet, salt, bitter, sour, and alkaline. Each series varied in intensity from a solution below the threshold to a strong solution. All five series were mixed together and the subject was required to sort them by taste. The weakest solution recognized was taken as the measure of the keenness

of taste. To obtain a statement for each sex, the results for each were averaged. Neither the method of making the test nor the treatment of results is above criticism. All the disturbing influences of after images, fatigue, and contrast enter into such a procedure as sorting tastes of varying quality and intensity. Any or all of these factors might conceivably vary with sex. Moreover, an average of results is not a fair expression of the ability of one class. One or two very abnormal individuals might change the average unduly. The limits within which the majority of the normal individuals of a class fall is the measurement required. Dehn experimented on the four accepted tastes. He used a single weak solution of each taste and recorded the right and wrong judgments.

Dehn, whose test is perhaps most closely comparable with the present one, finds women keener than men in all four tastes. Nichols and Bailey, in their tests on American students, find women keener than men in all tastes except salt, in which men are keener than women. Nichols obtains the same result in his experiments on Indians. Ottolenghi, experimenting with sweet, salt, and bitter, finds women somewhat keener than men, but attributes this fact to the use of tobacco by men and concludes that they are probably naturally keener than women. Lombroso, using three tastes, sweet, salt, and bitter, finds women keener in sweet and salt and less keen in bitter. Di Mattei, experimenting with children between the ages of four and twelve, finds the boys more sensitive than the girls in bitter, equal to them in salt and less sensitive in sweet. Roncoroni finds sensibility to sweet keener in women, but sensibility to bitter and salt keener in

men. The general result of all these tests is to show that women have lower thresholds for taste than men. The question remains as to whether or not this statement holds for all tastes. Four of the eight series of tests find an exception in the case of salt, and three in the case of bitter. Since there is no agreement about the exceptions, and the most accurate methods show women to be somewhat keener in all tastes, it seems probable that this is a correct generalization.

In discussions on the keenness of taste, the distinction between the threshold and the discriminative sensibility has not always been observed. It is ordinarily assumed that a low threshold means also a fine discriminative sensibility — an assumption which has no *a priori* justification, and which receives no support from the present series of tests. There are no other results on the discriminative sensibility for strong tastes to compare with the present series, but if these results are to be trusted, fine discriminative sensibility for strong tastes is to be correlated with a high threshold, rather than with a low one. When it is argued that women cannot have a finer taste than men, because all the professional wine- and tea-tasters are men, this distinction is overlooked. The tasting of wine and tea depends on the ability to discriminate strong tastes. Threshold tests throw no light on this question. The tests here reported show that men have a better discriminative sensibility for strong tastes than women, although their thresholds are higher than those of women.

There are on record eight sets of experiments on smell: those by Bailey and Powell (4), by Bailey and Nichols (5), by Ottolenghi (64), by Lombroso (51,

chap. iii), by Toulouse and Vaschide (80), by Garbini (28, 28a), and by Di Mattei (21). Lombroso does not state his method. Bailey and Powell, Bailey and Nichols, Ottolenghi, and Di Mattei used a method analogous to that of Bailey and Nichols in their experiments on taste, viz., sorting bottles. Bailey and his co-workers used five different odors and all the bottles were given to the subject at once. Ottolenghi used but one odor, and gave the bottles in groups, beginning with the weaker ones. This procedure diminished the disturbing factor of fatigue which is so important in smell. Di Mattei experimented on children of from four to twelve years. To the younger children he gave the bottles in two groups, while to the older ones he gave all the bottles at once. Both Ottolenghi and Bailey and his co-workers find that men are keener than women in smell, the latter reporting that men are about twice as keen as women. These results apply only to the threshold of smell. They are flatly contradictory to the outcome of our test, which finds what little difference there is in favor of the women.

The work that is most closely comparable to that of the present series of tests in method, is that of Toulouse and Vaschide. They used a single odor—camphor—began with the subliminal solutions, used distilled water as a control, and worked up to the threshold. Their subjects were hospital attendants. The outcome of the test is in accord with ours. They find a keener sense of smell in women than in men. Garbini's results, cited by Toulouse and Vaschide, agree with theirs. Di Mattei used the method of arranging intensities of a single odor with children,

and found that girls could detect a fainter odor than boys, and could arrange the series more accurately. Observations of Garbini (28a) confirm this result.

It is difficult to explain the contradiction in these two sets of results. Those experiments from which the factors of fatigue and contrast are excluded, show a keener sense of smell in women. Whether the presence of these factors in the other set of tests is sufficient to explain the difference, it is impossible to say.

GENERAL SUMMARY OF THE EXPERIMENTS ON TASTE AND SMELL.

With reference to the thresholds for taste there is practical agreement among all observers that women have lower thresholds than men. The only tests made on discriminative sensibility for strong tastes indicate that men are somewhat superior to women, a result which is in accord with their higher threshold.

There is a decided contradiction in the results of the experiments on smell. Three of the previous tests had indicated a lower smell threshold for men than for women. The tests performed with the greatest rigor of method, however—those of Toulouse and Vaschide and those of the present series—show a lower smell threshold for women. No difference in discriminative sensibility was demonstrated.

CHAPTER V.

HEARING.

SENSIBILITY to pitch was the only aspect of hearing experimented upon. No attempt was made to find the threshold for hearing, because the laboratory was not provided with a sound-proof room. Three determinations of sensibility to pitch were made, as follows:

A. The upper limit.
B. The lower limit.
C. Discriminative sensibility, with the 512 fork as a standard.

A. THE UPPER LIMIT.

The Galton whistle was the instrument used to investigate the upper limit of sensibility to pitch. The contrast between the shrill sound of the whistle where the pitch is perfectly distinct and the sound of the rush of air in the regions above the possible limit of pitch, was first given to the subject. He was then told to listen carefully to each stimulation given him and tell whether he could distinguish the shrill pitch sound, or whether it was merely the rush of air. The number of vibrations was gradually increased until the subject

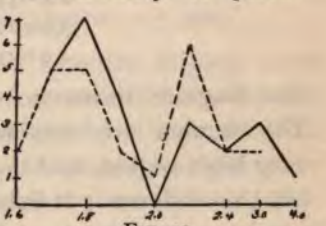

FIG. 42.

Upper limit of pitch.
Abscissas — scale readings of the Galton whistle.
Ordinates — number of subjects.
- - - - women; — men.

lost the pitch, and was then decreased until he heard it again. In the regions near the limit of discrimination he was given from four to six stimulations for each turn of a division in the vernier scale, and the point at which he heard the pitch three-fourths of the time was fixed upon as the upper limit.

The diagram of results (Fig. 42) is made out for convenience in terms of the scale-readings of the whistle. It will be easily interpreted if it is borne in mind that the smaller numbers on the scale mean higher vibration rates. The following table gives the number of vibration rates per second for each scale-reading which appears in the table:

1.6=52,500 vibrations per second
1.7=49,411
1.8=46,667
1.9=44,210
2.0=42,000
2.2=38,181
2.4=35,000
3.0=28,000
4.0=21,000

The diagram shows no characteristic sex difference. The women are somewhat more numerous in the very high region, and the men in the very low region, but this difference is balanced by the fact that there are more men in the middle high ranges, and more women in the middle low ranges.

B. THE LOWER LIMIT.

The experiments on the lower limit of pitch were performed with the Appunn wire forks. There were eight forks in the series, ranging from twelve to fifty-six vibrations per second. Each fork is repre-

sented in the abscissas of the curves of results (Fig. 43). Since the lowest fork (twelve vibrations per second) was not below the possible limits of pitch, the subjects could not in this case be given the contrast between pitch, and vibrations with no pitch. The experiments were begun with the forks of high vibration rate, and worked down to the limit. The subject kept his eyes closed during the test. Each fork was sounded close to his ear several times. He was asked to tell each time whether the sound he heard could be called a tone or not. The lower limit of pitch is subjectively much harder to fix than the upper. As the vibration rate decreases, the smooth singing tone changes into a pulsating sound which still has a certain pitch quality. Many subjects found it very difficult to fix upon the point where the sound lost its pitch quality. An attempt was made to control the judgment by requiring discriminations of higher and lower in doubtful cases, but this proved to be impracticable; in the first place, because discriminative sensibility at the lower limit is so coarse; and in the second place, because the difference of vibration rate could be felt as the air struck the ear and an indirect judgment as to pitch, based on vibration rate, was unavoidable. The results therefore contain the source of error due to differences in individual standards.

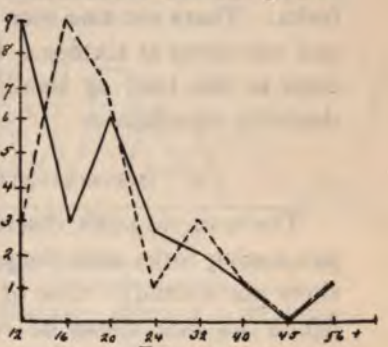

FIG. 43.

Lower limit of pitch.
Abscissas — vibrations per second of the forks used.
Ordinates — number of subjects.
---- women; —— men.

The result (Fig. 43) seems to indicate a somewhat lower limit of pitch in the men. The limits of the two curves are the same—from twelve to above the series of forks; the difference in them is in the number of lower limits falling on the twelve and sixteen forks. There are nine men and three women at twelve and *vice versa* at sixteen. Considering the source of error in the test, as small a difference as this is of doubtful significance.

C. DISCRIMINATIVE SENSIBILITY.

The tests on pitch discrimination were made with two tuning forks with the pitch Ut 3 (512 single vibrations per second). One of the forks bore a rider by which its rate could be reduced as much as seven vibrations per second. The forks were mounted on wooden resonators. The subject sat with his back to the apparatus, at a distance of about six feet. The forks were sounded by tapping them with a rubber-tipped hammer. The chief source of error in the test was the inequalities of intensity incident to striking the forks by hand. Long practice reduced this to a minimum, and any tests where the differences of intensity were noticeable were discarded.

The usual directions for discriminative tests were given the subject. He was told that two tones would be sounded in succession and that he was to report each time which of the two was higher in pitch. The number of tests in each order was the same. The series began with the large differences—six or seven vibrations per second—and worked gradually down to the limit. Most of the subjects improved so rapidly with practice that it was found necessary to keep the

time devoted to this test approximately constant. A few subjects came to a standstill before the end of the half-hour usually allotted to it and proved unable to go farther even after repeated trials. In these cases the test was stopped when improvement ceased. In all other instances the fineness of discrimination reached at the end of the half-hour is what is recorded. It may not in all cases represent the limit of possible discrimination, but is a fair measure of the relative natural capacities.

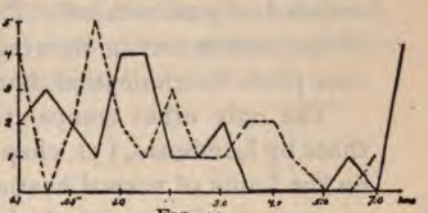

FIG. 44.

Pitch discrimination. Standard, Ut_3 (512 single vibrations per second).
Abscissas — difference in the number of vibrations per second between the standard fork and the fork of comparison necessary for discrimination.
Ordinates—number of subjects.
---- women; —— men.

The results (Fig. 44) are recorded in terms of the difference of vibration rate between the two forks at the limit of discrimination for each subject. The curves indicate finer discrimination in the women than in the men. The difference is shown principally by the greater number of women than men who could discriminate a difference of less than one vibration a second, and the preponderance of men who could not discriminate pitch at all within the limits allowed by these forks. The latter subjects seemed to have no clear idea of what the terms high and low meant with reference to pitch. Their attempts at discrimination were pure guesses, with no discernible regularities.

SUMMARY OF OTHER EXPERIMENTAL WORK ON HEARING.

The only test on pitch comparable with ours is the one made in the series of tests at Columbia University (82). The method consisted in requiring the subject to find again, after the bridge had been shifted, a note sounded on a monochord. The result agrees with that of the present test in showing that the women have a finer pitch discrimination than the men.

The only other comparative tests on hearing are those by Lombroso, (51, chap. iii) and Roncoroni (72) on the limits of normal hearing. They both used as a measure the distance at which a watch could be heard. Although the number of persons tested was small, the method rough, and the results contradictory for the two ears, Lombroso comes to the conclusion that men's hearing is keener than women's. Roncoroni agrees with him.

Reik (71) reports an interesting anatomical investigation of the ears of 440 school children. He found abnormalities much more frequent in the ears of boys than in those of girls. He also made investigations on the physiological functions of the ear. Although he gives no report of his results on pitch discrimination, the presumption is that it would be poorer in the sex with the greater number of abnormalities — a result which would be in accord with ours. The values he obtained for the upper limit of pitch agree very well with ours. Some of the children, however, could distinguish higher vibration rates than any of our adult subjects. He makes no comparison of sex with respect to the upper limit. Tests made under the direction of F. W. Smedley (71a) in the Chicago public schools revealed no great differences as regards defective hearing in boys and girls.

GENERAL SUMMARY OF TESTS IN HEARING.

In the upper and lower limits of pitch the only difference of sex indicated was a possible lower limit for men. In pitch discrimination women are better than men. The tests on the threshold for hearing have been too few in number, too rough in method, and too contradictory in result to serve as a basis for any trustworthy generalization.

CHAPTER VI.

VISION.

THE experiments made on vision dealt with the following subjects :

A. The threshold for light.
B. Discriminative sensibility for brightness.
C. Keenness of vision.
D. Discrimination of color.
E. Discrimination of visual areas.

A. THE THRESHOLD FOR LIGHT.

The apparatus used in the experiments on the sensitiveness of the retina to light was a long wooden tube about eight inches square at the ends and four feet long. It was blackened on the inside and was made absolutely light-proof. At one end was a box-like cover under which the subject could sit, with his eyes on a level with the tube. When the subject was in position, the box was covered with a camera cloth in such a way that no light could reach his eyes. At the other end of the tube was a round opening one inch in diameter. It was found impossible to reduce white light to the threshold. The opening was therefore covered with violet glass. Since all light appears as mere brightness in its lowest intensities, the color of the glass was indifferent in the present case. The glass was held in place by a box-shaped cap which fitted over the end of the tube. The circular opening was closed by a round black disc. When the disc was in

position no light whatever could reach the eye of the subject. The only possible way to stimulate the retina was to move the disc away from the opening in the tube.

The experiments were made in a completely dark room. The source of light was a Welsbach burner. One of the great difficulties in making experiments on the threshold of vision has been to find some way of reducing the light by measurable amounts. In this case no attempt was made to reduce the illumination itself. A source of light which would remain constant was all that was required, and other means presently to be described were taken to lessen the intensity. A year's experience with the apparatus previous to using it in this test was sufficient to convince us that the Welsbach burner, under full gas pressure, does furnish a constant source of light. The supply of gas is always sufficient to illuminate the mantel to its full extent, and that insures the maximum of light which the burner affords. It was found that the same threshold—allowing for variations in temporary condition—could be established for a given subject day after day with this apparatus. Assuming therefore that what variations of intensity there were in the source of light were beneath perception when applied in this way, the intensity was reduced to the amount required by shading the light in various ways and reducing reflection in the room. A few inches in front of the opening of the tube was placed a black cardboard screen at a given angle with the box and with the burner. The burner was placed opposite the black screen about five feet away, and shed its light on the screen, from which it was reflected into the box whenever the open-

ing was exposed. The burner itself was placed in a case with a window opening toward the screen. This reduced reflection from the walls of the room. By this means the amount of light admitted to the box was lowered to a point near the threshold. The further diminution of intensity was accomplished by a series of cheese-cloth curtains which hung in front of the window of the case containing the burner. Every curtain lowered reduced the illumination of the black screen and consequently the amount of light entering the box. Since all the other factors in the situation remained constant the absolute sensitiveness of the retina could be measured by the number of curtains necessary to reduce the illumination to the least visible amount.

There were two time factors in the experiment which it was necessary to keep constant. One was the length of time the eyes were rested in the dark box before the experiment began, and the other the time of exposure of the light for each stimulation. The former was important because the sensitiveness of the retina increases fast on being completely protected from light. If the experiments were made a few minutes after the subject was put into the apparatus, the threshold found would be much higher than that found half an hour later. It was observed that after an hour the sensitiveness increased little if any. Consequently, the subjects were left entirely without stimulation of the retina for thirty or forty minutes. This time was used for determining the touch threshold (see chap. iii, sec. A, 1) and the discriminative sensibility for area on the skin (see chap. iii, sec. B, 2). At the end of that time the experiments on the eyes were begun, and were completed in twenty or twenty-

five minutes. The sensitivity registered is that which obtains after protection of the retina from light — except the minimal stimulations of the test — for an hour.

The second time element — the duration of the single stimulations — is important because a very faint light may be visible when exposed for a longer time but not visible when exposed for a shorter time. This time interval was controlled by a mechanical contrivance for raising and lowering the disc covering the opening in the dark box. The disc was fastened by a projection at one side to the end of a vertical rod, in such a way that when the rod was moved up about half an inch, the disc was thrown down, uncovering the opening. The other end of the rod was joined by a pivot to the end of one arm of a lever which was mounted on the table. The fulcrum of this lever was a ball and socket bearing at its middle point. The downward pressure of the rod on one arm was balanced by a movable weight on the other arm. By means of this adjustment it was possible to bring the system into a state of equilibrium such that the lever arms would remain as they were placed. When the arm connected with the rod was moved up by pressing down on the free lever arm, the disc was thrown down and the box opening remained uncovered. It was closed again at the end of the required interval by means of a metal ball which rolled down a trough and into a second short trough which was fastened to the upright rod. A catch was arranged which held the balls in place until time to release them. When the free lever arm was pushed down, it removed the disc from the box opening, and at the same instant released

the catch which held the ball. The opening remained uncovered until the ball rolled down the trough and into the short trough borne by the rod. The weight of the ball then carried the rod down and thus threw the disc up over the opening again. The duration of each stimulation was the time required for the ball to roll from the catch to the short trough. As long as the length of trough employed and its inclination remained the same, the ball's time remained practically constant. Its variations were far within the limits of the time error for this experiment. The troughs were padded to make them noiseless. A padded inclined plane was arranged which received the ball as it left the trough and returned it to the operator.

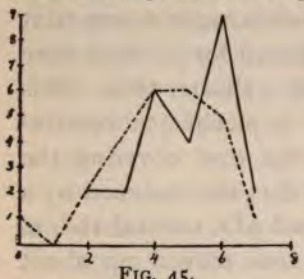

FIG. 45.

Light threshold.

Abscissas — number of curtains down.

Ordinates — number of subjects.

---- women; —— men.

The series of tests was begun with a light which was clearly above the threshold, to make sure that the subject was familiar with the stimulus. The stimulations were given in series of ten at irregular intervals. The subject was required to count aloud when he saw the light. As soon as the threshold was approached, two or three series were given for each grade of intensity. Rests of several minutes were allowed between series. When the subject was troubled with retinal activity which obscured the field of vision with clouds of gray or colored light, longer periods of rest were given for these to subside. As in other threshold tests, imaginary stimulations were inserted in the series

by most subjects. If the tendency proved extreme, the subject was told of it, and in such cases it invariably decreased. The point taken as a threshold was the least intensity — measured in terms of the number of curtains lowered — at which three-fourths of the stimulations could be correctly counted, regardless of the imaginary ones inserted.

The results (Fig. 45) show an appreciably greater sensitiveness of retina in the men than in the women. Men are decidedly more numerous in the region of greatest sensitiveness (six to seven curtains), and less numerous in the regions of slight sensitiveness (none to three curtains).

B. DISCRIMINATIVE SENSIBILITY FOR BRIGHTNESS.

The Bradley color wheel, with two sizes of black and white discs, was employed for testing the discrimination of brightnesses. The smaller circle was made the standard. It remained half black and half white throughout the test. The proportion of black and white in the larger circle was shifted until the least amount of black necessary to make the outer ring appear darker than the inner circle was discovered. A disc with a circle divided into one hundred parts placed behind the large discs served to measure the amount of black added to the outer circle. The record was kept in terms of the percentage of black required in the outer ring to make it just perceptibly darker than the inner circle.

To insure a constant illumination, the tests were made in a dark room, and the light was furnished by a Welsbach burner placed at a fixed distance behind the subject in such a way that the light came over the

left shoulder. The subject was seated facing the wheel. His eyes were kept closed during the shifting of the discs, and were not opened until the wheel was in full motion again. The only direction given the subject was that he was to tell each time whether the inner circle or the outer was darker. To avoid the error of having the outer circle constantly the darker, frequent tests in which the outer circle was lighter were inserted in the series. The test began with clearly distinguishable differences, and worked down, shifting back and forth, to the finest possible discrimination. Three out of four correct judgments served to fix the limit of discrimination. The discrimination was measured to fourths of 1 per cent.

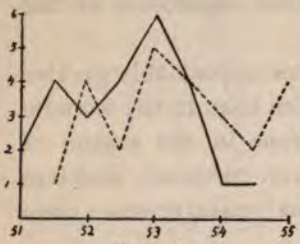

FIG. 46.

Discriminative sensibility for brightness. Standard, 50 per cent. black and 50 per cent. white.

Abscissas — percentage of black necessary for discrimination.

Ordinates — number of subjects.

- - - - women; —— men.

The results (Fig. 46) show a better discrimination on the part of the men. Their curve is above that of the women in the region of fine discriminations (51–53 per cent.) and below it in the region of coarse discriminations (54–55 per cent.).

C. KEENNESS OF VISION.

The apparatus used for testing keenness of vision consisted of cards, one black and one white, about four inches long and five inches wide, on each of which were pasted little squares (2 mm.), of red, blue, green, and yellow. The black card had also a white square,

and the white card a black square. The five squares were pasted at equal distances along the center of the cards. The subject was tested first with the white background, and second with the black background.

The tests were made in a dark room. The card was illuminated by the light of a Welsbach burner placed at a fixed distance from it. A screen behind the light protected the subject's eyes from it as he approached. The card was hung on the wall on a level with the subject's eyes. From the point below the middle of the card, a 5 m. line was marked across the room on the floor. The subject was placed at the end of this line, with one eye bandaged. The card was hung upon the wall, and the subject was asked how much he could see on it. He was then directed to approach slowly, telling at each step how much he could see, until all the squares and their colors were visible. The point at which each square and each color became visible was noted. With thirteen subjects of each sex the right eye was used first, and with twelve the left eye. The spots were, of course, visible much farther away than their colors. In order to make the subject careful in observing, he was asked about the appearance of the spots at each step, and particularly whether or not they all looked gray or black. After testing one eye, a pretense was made of changing the card for the other eye, in order that the subject might not be influenced by a knowledge of what was really on the card

The test did not prove to be altogether a satisfactory one, because the maximum distance from the

card, 5 m., was not sufficient to make the spots disappear to the normal eye, on either background. The blue spot on the black ground, and the yellow spot on the white ground, were not visible to most subjects at 5 m. The colors on the white card were very rarely visible at the end of the line. On the black card the red and green could be distinguished by a number of subjects.

The results of these tests bearing on the threshold for the perception of the spots appear in Table X. About all that can be gathered from this table is that there are more men than women with weak left eyes. The records for the blue on the black ground, and for the yellow on the white ground, do, however, afford some means of judging of the status of those who, in the other combinations, fall beyond the limits of the test, *i. e.*, 5 m. In these two instances, the right-eye test shows the men somewhat better than the women, and the left-eye test shows them very slightly inferior.

The results bearing on the threshold for the recognition of the colors of the spots are shown in Table XI. In this table the combinations, black on a white background and white on a black background, do not appear, because for them the threshold of perception was the only one obtainable. The difference between the sexes is more marked in the recognition of color than in the perception of the spots. In the latter respect the right eye is superior among the men; in the recognition of color it is superior among the women. There are but two instances, blue and yellow on white, in which it is superior in the men. In two more, green on white, and yellow on black,

TABLE X.

Keenness of vision. Thresholds of perception for the several spots, *i. e.*, distances at which the spots were perceived.

Distance of Subject from Card (Decimeters).				0	5	10	15	20	25	30	35	40	45	50
	Black on White B'kground.	Left. Right.	Women.	..	1	..	2	..	..	..	..	..	3	19
			Men ...	..	..	..	1	1	..	1	1	..	2	19
			Women.	..	..	1	1	..	..	..	..	..	..	23
			Men ...	1	..	1	2	..	1	..	1	..	..	19
	White on Black B'kground.	Left. Right.	Women.	..	..	1	..	..	1	1	..	..	..	22
			Men ...	..	..	..	..	1	..	..	1	..	..	23
			Women.	..	..	1	..	..	..	..	..	1	..	23
			Men ...	1	..	..	..	1	2	..	..	..	1	20
Blue.	Black Back-ground.	Left. Right.	Women.	..	..	2	1	1	1	2	2	4	4	8
			Men ...	..	..	1	1	1	1	2	1	3	3	12
			Women.	..	1	..	1	..	1	2	2	4	6	8
			Men ...	1	..	2	1	1	2	1	1	3	2	11
	White Back-ground.	Left. Right.	Women.	..	1	1	1	..	..	..	.	..	2	20
			Men ...	..	..	..	1	1	..	1	1	..	2	19
			Women.	..	..	1	1	..	..	..	..	..	..	23
			Men ...	..	..	1	2	..	1	1	..	..	..	19
Green.	Black Back-ground.	Left. Right.	Women.	..	..	1	1	1	..	..	..	1	..	21
			Men ...	..	..	..	1	..	1	..	..	..	..	23
			Women.	..	..	1	..	..	1	..	..	..	..	23
			Men ...	1	..	..	2	1	..	..	1	1	..	19
	White Back-ground.	Left. Right.	Women.	..	1	1	1	..	..	..	..	1	1	20
			Men ...	..	..	..	1	1	..	2	..	1	1	19
			Women.	..	..	1	1	..	..	..	..	..	..	23
			Men ...	1	..	1	2	..	1	..	1	..	..	19
Red.	Black Back-ground.	Left. Right.	Women.	..	..	1	1	1	..	..	1	..	..	21
			Men ...	..	..	..	1	1	..	..	1	1	1	20
			Women.	..	1	..	..	..	1	..	..	..	1	22
			Men ...	1	..	..	2	1	..	..	1	1	1	18
	White Back ground.	Left. Right.	Women.	..	1	1	1	..	..	..	..	..	2	20
			Men ...	..	..	..	1	1	..	..	2	..	2	19
			Women.	..	..	1	1	..	..	..	..	..	..	23
			Men ...	1	..	1	2	..	1	..	1	..	..	19
Yellow.	Black Back-ground.	Left. Right.	Women.	..	..	1	..	..	1	1	..	1	..	21
			Men ...	..	..	..	..	1	..	..	1	..	1	22
			Women.	..	1	..	..	..	..	..	..	1	..	23
			Men ...	1	..	..	..	1	2	..	..	..	2	19
	White Back-ground.	Left. Right.	Women.	..	1	2	..	2	6	7	3	4	..	..
			Men ...	..	..	1	1	5	4	3	5	5	1	..
			Women.	..	1	1	..	2	6	4	6	4	..	1
			Men ...	1	..	2	2	3	2	5	4	3	2	1

TABLE XI.

Keenness of vision. Thresholds of recognition for the various spots, *i. e.*, distances at which the color of the spots was recognized.

Distance of Subject from Card (Decimeters).				0	5	10	15	20	25	30	35	40	45	50
Blue.	Black Background.	Right.	Women.	..	2	2	2	6	4	4	4	..	..	..
			Men ...	..	3	3	4	4	2	4	3	1	1	..
		Left.	Women.	..	2	1	3	6	5	..	2	3	3	..
			Men ...	1	2	4	6	5	3	1	2	..	1	..
	White Background.	Right.	Women.	..	14	8	1	2	..	..	..	..	..	..
			Men ...	3	11	4	6	..	1	..	..	..	..	..
		Left.	Women.	..	12	9	2	1	..	..	..	..	..	..
			Men ...	5	16	1	2	1	..	..	..	..	..	..
Green.	Black Background.	Right.	Women.	1	..	1	2	1	1	1	3	3	6	6
			Men .	1	..	..	4	..	4	1	1	3	1	9
		Left.	Women.	1	1	..	1	..	2	2	1	2	7	8
			Men ...	2	..	4	2	..	2	3	2	2	1	7
	White Background.	Right.	Women.	1	5	6	5	4	2	1	1	..	..	..
			Men ...	1	3	8	5	4	1	1	1	..	1	..
		Left.	Women.	1	4	3	9	3	2	..	1	..	1	1
			Men ...	2	5	6	5	1	1	3	1	1	..	..
Red.	Black Background.	Right.	Women.	..	..	1	2	1	..	..	1	3	7	10
			Men ...	1	..	..	..	2	..	2	4	..	2	13
		Left.	Women.	..	1	..	1	..	..	..	1	3	4	15
			Men ...	1	..	1	4	..	1	..	2	3	..	13
	White Background.	Right.	Women.	..	2	2	6	4	4	2	2	1	1	1
			Men ...	2	..	3	5	5	4	3	2	1	..	..
		Left.	Women.	..	2	1	5	3	7	3	2	1	..	1
			Men ...	3	3	3	4	6	1	2	1	2	..	..
Yellow.	Black Background.	Right.	Women.	..	1	2	2	3	4	1	1	5	3	3
			Men ...	..	..	3	5	1	1	3	3	2	..	7
		Left.	Women.	1	1	..	3	3	4	3	2	1	4	3
			Men ...	1	1	2	3	3	1	2	6	..	.	6
	White Background.	Right.	Women.	..	10	8	6	1	1	..	..	..	..	..
			Men ...	1	8	4	8	..	4	..	..	..	..	..
		Left.	Women.	..	6	9	6	3	..	..	..	..	..	1
			Men ...	1	10	1	8	4	1	..	..	..	..	..

it is practically the same for both, and in the other four combinations it is better in the women. The left eye has a better record among the women in all colors except yellow, in which it is somewhat better in the men. The superiority of the women is more marked in the recognition of red and green than in the recognition of blue and yellow. Yellow is the only color for which the men's record is better than the women's. The general conclusion is that the men's eyes are possibly somewhat keener than the women's in the detection of the presence of an object, but quite surely less keen in the recognition of its color. The former statement is qualified because the test was not well devised for determining that point, and the data on which it is based are meager.

D. DISCRIMINATION OF COLOR.

The test regarding the discrimination of color was made with the larger series of Holgrem worsteds for testing color-blindness. The worsteds were given to the subject heaped upon a gray cloth. He was given a sample to serve as a standard, and was told to select all the worsteds in the pile which were of the same color as the sample. It was carefully explained that the worsteds might differ in shade from the sample, but must not differ in hue. When the required worsteds were selected, he was told to arrange them in order from lightest to darkest. The samples were given in the order—green, blue, red, and yellow. After each series was selected it was mixed into the pile before the selection of the next one began. The subject was marked "color-blind" only in undoubted cases, where decided oranges were

placed with yellows, lavenders with blue, or browns and grays in the color series. When bad mistakes were made, but not bad enough to rank the subject as unquestionably color-blind, he was marked "poor" in color discrimination. The series in which the mistakes were very slight were graded as "medium," and those which were perfect were recorded as "excellent."

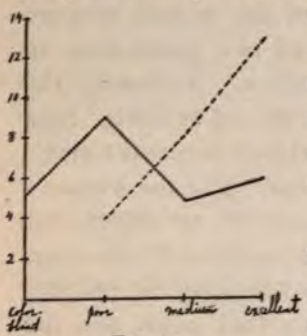

FIG. 47.

Discrimination of color.
Abscissas — grades of discrimination.
Ordinates — number of subjects.
---- women; —— men.

The curve for the discrimination of color (Fig. 47) shows a strikingly better color discrimination in the women than in the men. The men predominate in the "color-blind" and "poor" sections, and the women in the "medium" and "excellent."

E. DISCRIMINATION OF VISUAL AREAS.

For the tests on discrimination of visual areas a series of small white squares mounted on large black cardboard squares was used. The size of the black squares, and the position of the white squares on them, were identical throughout the series. The standard square measured 20 mm. on a side. Those for comparison were 19.5, 19, 18.5, and 18 mm. The subject sat at a table facing a black screen. The experimenter stood behind the screen and placed the two squares to be compared in front of the screen successively. The directions were to report which of the two squares

shown was the larger. The series began with the larger differences and worked down to the smaller. The point at which three-fourths of twelve judgments were correct was taken as the limit of discrimination.

The curves for the discrimination of visual area (Fig. 48) are very similar for the men and the women. What difference there is is in favor of the men. They are somewhat more numerous in the region of finest discrimination (19.5 and 19.5 mm.+).

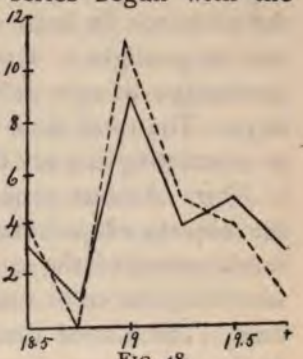

FIG. 48.

Discrimination of visual area. Standard square, 20 mm.

Abscissas—size of squares just discriminable from the standard.

Ordinates—number of subjects.

---- women; —— men.

SUMMARY OF OTHER EXPERIMENTAL WORK ON VISION

There are no tests to compare with the present series on the absolute sensitiveness of the retina to light or on the discriminative sensibility for grays, and none exactly comparable with the test on keenness of vision. Those which are on record employed the method of reading type or numerals. Pearson (69) reports a series of measurements on men and women at Cambridge, in which the average is slightly higher for the men with the right eye and for the women with the left eye. The Columbia University tests (82), in which the same method was used, revealed no difference in sight. The present test happens to coincide with the Cambridge results in showing the right eye

slightly better among the men, and the left eye among the women. In both cases, however, the differences are very slight. Krauskopf (43) found a greater percentage of eye defects among girls than among boys. The total mass of results does not warrant us in postulating any sex difference in keenness of vision.

Three distinct problems in color vision have been the objects of previous investigations: the absolute sensitiveness of the eye to color; the discriminative sensibility for color; and the presence of color-blindness. The first of these was investigated by Nichols (62). He prepared series of mixtures of white powder with colored pigments for the four colors, red, green, blue, and yellow. The series varied in intensity from mixtures indistinguishable from white, to clearly colored mixtures. The series for the four colors were placed in glass bottles, and the bottles were indiscriminately mixed. The subject was required to sort them according to hue and shade. Nichols found that men were able to distinguish smaller amounts of pigment than women in all colors except blue, in which women excelled. This result is not in accord with that of the present series of tests, which finds women more sensitive than men to all colors except yellow.

With regard to the second problem — the ability to discriminate shades of a single color — all observers agree with our result, *i. e.*, that women are superior to men. Lombroso (51, chap. iii) reports that women are three times as keen as men in distinguishing colors with the Holgrem worsteds, a difference which he attributes to their practice in embroidery. Nichols, in the test reported above, finds that

women are better than men in arranging the series of colors according to intensity. Gilbert (30) and MacDonald (55, p. 1106) both report that among school children girls are better than boys in distinguishing the shades of a single color. Luckey (53) seems to be alone in his doubt about a sexual difference in this respect. He reports experiments on a good many children and a few adults, and says that he finds the color range and the power of discrimination in the primary colors equal for the two sexes.

The investigations which have been made regarding the third problem — the presence of color-blindness — may be said to have established without question the fact that this defect is more frequent among men than among women. Jeffries (40, 41, 42) reports tests on large numbers of persons both in this country and in Europe which show a decidedly larger percentage of color-blindness among males than among females. Mullen (59) collected the reports on tests for color-blindness made in the United States, France, England, Denmark, Sweden, Russia, Austria, China, and Japan between the years 1880 and 1897. In all of these reports in which a comparison of sex was made, the percentage of color-blindness was much higher among men than among women. Wissler (82) corroborates these findings in his report of the tests on Columbia University students, and it holds for the present series of tests on University of Chicago students.

No comparative test (other than that of the present series) on the judgment of visual areas is on record. MacDonald (55, p. 1104) reports a test on school children in the estimation of the length of a line.

In that, as in the present test on judgment of area, the males were somewhat more accurate than the females.

GENERAL SUMMARY OF EXPERIMENTS ON VISION.

The generalization suggested by the experiments on vision is that on the whole men are somewhat better than women in brightness vision, while women are better than men in color vision. Although no difference between the two in keenness of vision has been established, men's eyes are shown to be absolutely more sensitive to light than women's, and they make finer discriminations of grays. The results as to the absolute sensitiveness of the eye to color are contradictory. Nichols finds it greater in men, and the present test shows it greater in women. There is general agreement, however, that women discriminate color better than men, and are less subject to color-blindness. The tests on visual discrimination of area and on estimation of length show that in this faculty males are somewhat superior to females.

CHAPTER VII.

INTELLECTUAL FACULTIES.

THE investigation of the intellectual faculties covered four different fields:

A. Memory.
B. Association.
C. Ingenuity.
D. General information.

A. MEMORY.

The memory factors investigated were the rate of memorizing, retentiveness, and the nature of the imagery employed. The material to be memorized consisted of two series of nonsense syllables, each series containing ten syllables. The first series ("mon, yit, zev, yer, zam, kig, sef, gav, cim, nis") was read aloud, and the second ("huc, cir, suv, nif, fom, mep, yom, fim, zok, seb") presented visually.

In both cases the syllables were given at the rate of one per second. To avoid rhythm and secure a constant rate of presentation for all subjects, they were timed by a metronome. The auditory series was read aloud as distinctly as possible, the visual series was placed on a stroboscopic drum and displayed syllable by syllable behind an opening in a black screen. The auditory series was learned first in each case, and the visual series immediately afterward at the same sitting.

The subject was given no directions about the way

he should do the memorizing. He was merely told that the series of syllables would be given him as many times as he needed it to learn it correctly. A pause of from twelve to fifteen seconds intervened between successive presentations. As soon as the subject thought he knew the series, he began to say it aloud in the interval between presentations. If it were not correctly said, the readings continued until it was. After it was learned the subject was asked to describe accurately the type of imagery he had used in memorizing, to tell whether or not he had learned the series by means of associations, and to report any tendency to group the syllables in learning them.

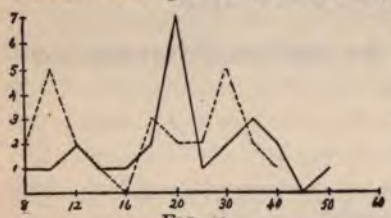

FIG. 49

Memory. Rate of memorizing. Auditory series.
Abscissas — number of repetitions.
Ordinates — number of subjects.
- - - - women; —— men.

Retentiveness was measured by the number of repetitions required to memorize the same series just one week after the first memorizing. The subject was not told that he would be required to memorize them a second time; the hours were merely arranged so that he came to the laboratory just a week after the first memorizing. In almost all cases the subjects said that they had made no effort to repeat the syllables since the first memorizing. A few had tried it simply out of curiosity, and one of the men suspected that he would be asked to memorize them a second time and had made a special effort to remember them. There were two women and two men who failed to appear at

the hour when the second memorizing should have taken place. In these instances the interval was from one to three days over a week. The abnormally slow second learnings do not, however, coincide with these longer periods According to the well-known psychological law of forgetting, there is very little difference, so far as memory is concerned, between a period of seven days and one of nine or ten. Aside from this consideration, however, the exceeding of the regular period by these four subjects may be disregarded in comparing the men's retentiveness with the women's, because two of them were men and two women.

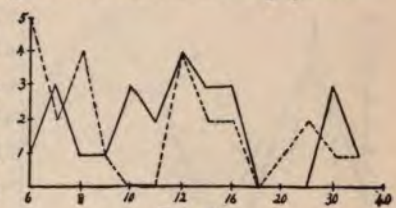

FIG. 50.

Memory. Rate of memorizing. Visual series.
Abscissas—number of presentations.
Ordinates—number of subjects.
- - - - women; —— men.

Figs. 49 and 50 are the curves for the first memorizing of the two series. The auditory series has a total average considerably greater than that of the visual series. No subject learned the auditory series in less than eight repetitions, while a number learned the visual in six. Not more than thirty-five repetitions were required in any case for the visual series, while the auditory series has fifty-five as its upper limit. There are two factors which are adequate to explain this difference. The first, and by far the most important, is that the habit of memorizing by means of printed symbols is universal, while very few, if any, of the subjects had ever formed the habit of learning material that is read aloud. Moreover, the visual symbols are more easily grasped in the first instance

than the auditory. The second factor which might tend to shorten the time of the visual series is that it was learned second in each case, and therefore had the benefit of the practice obtained in learning the auditory series. Since nonsense syllables were completely unfamiliar material for memorizing, the first series presented the additional difficulty of getting accustomed to a new subject-matter.

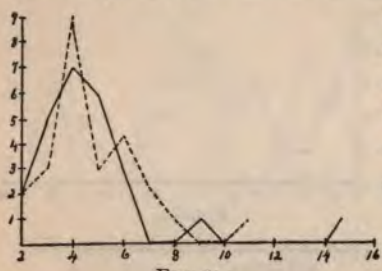

FIG. 51.

Memory. Retentiveness. Auditory series.
Abscissas — number of repetitions.
Ordinates — number of subjects.
- - - - women; —— men.

In both the auditory and the visual series the women show distinctly greater power of memorizing than the men. Here, again, we find both men and women at both extremes, but there are in both cases more women than men who memorized quickly.

Retentiveness was found to be practically the same for both the men and the women (Figs. 51 and 52). In the auditory series the curves for retentiveness correspond very closely. In the visual the women are slightly better, but the difference is too small to be of any significance.

Since the women are thus shown to have a greater power to memorize nonsense syllables than the men and an equal power to retain the memory, they may be said to have, on the whole, better memories for such syllables than have men. The question arises whether this fact justifies a general statement that women are superior to men in the faculty of memory.

If what we wish to measure is mere power of memory, isolated as far as possible from the factors of reason and association, nonsense syllables are universally conceded to be the best material. The results would justify us, therefore, in the statement that memory in its purest form is better among women than among men.

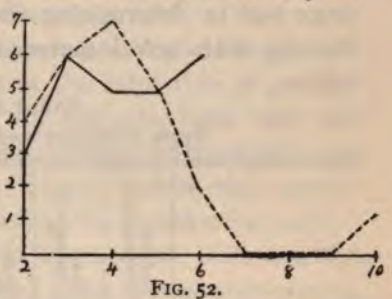

FIG. 52.

Memory. Retentiveness. Visual series.

Abscissas — number of repetitions.
Ordinates — number of subjects.
- - - - women; —— men.

A record was also made of the type of imagery used by each person in memorizing the syllables. The difficulty of making exact and adequate observations of one's own imagery is great even for individuals with special training, and is still greater for the unpracticed. The results in the present case were made as trustworthy as possible by questioning each subject at once and carefully as to the exact nature of his mental procedure. The great variety of combinations of imagery used makes their tabulation in significant form difficult. The scheme which has been followed in the present case is to classify all the cases in which imagery of the same sort predominates together. For instance, all the cases in which auditory imagery is predominant are put together. Among these are some in which only auditory imagery was used, and some in which visual, or motor, or both, were secondary to the auditory. Where two or three types of imagery were used so equally that no one could be called predominant,

the case is classified according to the components, as auditory-motor, visual-motor, etc. It is of course impossible to assert that the type of imagery used in this particular piece of memorizing is characteristic for the thinking of an individual, but habit must play a large part in determining the imagery to be used in dealing with novel material, such as nonsense syllables.

TABLE XII.

Types of imagery used in memorizing.[1]

		Auditory Predominant.	Visual Predominant.	Motor Predominant.	Auditory-Motor.	Visual-Motor.	Auditory-Visual	Auditory-Visual-Motor.
Audit. Series.	Women....	4	9	3	7	1	..	1
	Men.....	13	5	2	3	2	..	..
Visual Series.	Women....	1	10	6	2	4	..	1
	Men.....	8	8	2	1	2	1	2

Table XII gives the classification of the types of imagery. It shows that there were more men than women in whom auditory imagery was predominant, while women were more numerous in the visual and motor types. This statement holds for both the auditory and the visual series. The same tendency is further illustrated by the fact that when the series is given auditorially there are far more men in the auditory division than in the visual. When the series is given visually the relation is not reversed, but the visual presentation tends to induce visual imagery, with the

[1] In the visual series only twenty-four men and twenty-four women are tabulated. The record of the type of imagery was omitted by mistake in two cases.

result that the men are about equally divided between the two classes. The same holds true with reference to visual imagery. In visual presentation there are far more women in the visual categories than in the auditory, while in auditory presentation they are more equally divided between the two.

No differences were discoverable in the use of associations in memorizing or in the formation of groups. The great majority of the subjects, both men and women, learned the series in groups. In most cases the first and last groups were learned before the middle. The syllables from the sixth to the eighth were particularly hard. About half of the subjects, both men and women, used associations of some sort in memorizing. These were of the most various kinds. Some were associations of a few syllables with words; a few subjects associated most of the syllables with words; some associated each syllable with a finger tip; and one subject was obliged to connect each syllable with a spot on the wall before he could remember them. In a few cases the first letters were associated, or the vowels of successive syllables. But none of these schemes were characteristic of either sex.

The results of the memory tests may be summarized as follows: Judged by the approved memory test, *i. e.*, the memorizing of nonsense syllables, the women memorize more rapidly than the men. There is no difference between the men and the women in retentiveness. In memorizing nonsense syllables visual imagery is more common among the women and auditory among the men. No difference between the sexes was discovered in the use of associations in memorizing, or in the habit of memorizing in groups.

B. ASSOCIATION.

Experimental research in the field of association has been directed to two different problems: first, the nature of the relation between the idea furnished and the idea called up, or the quality of the association; and second, the rapidity with which the associated idea follows the given idea, which is a quantitative measure of the association process. Only the second of these two problems, that of the rapidity of the association process, was investigated in this series of tests. An attempt was made to deal also with the qualitative aspect of association, but it was abandoned for two reasons: first, because the classification of the associations, when obtained, was so difficult; and second, because it was so hard to obtain satisfactory results from untrained subjects. Until there is more unanimity in the psychological world about the best classification of associations, and the evaluation of the classified results, it seems useless to employ the test for a comparative study. Moreover, the test is a difficult one to apply. Many subjects when asked to write down the first word or phrase which comes in association with a given word find themselves quite at a loss. They insist that what comes naturally is not some other word or phrase, but first the image of the word itself, and second, some scene or train of ideas which it starts. If a single word or phrase is required the process seems entirely forced and bizarre to them.

The quantitative test, on the other hand, proved to be much easier to make, and its results are easily formulated, though perhaps not easily interpreted. The method employed was that of requiring the subjects to write down as rapidly as possible for a fixed time

the train of ideas started by a given word. In order to make the process as natural as possible no restrictions whatever were made upon the field of association. The subject was not required to come back to the word given for each fresh association. He was told to be just as natural as possible; to let his thoughts take their course, whether that consisted in clinging to the given word or in wandering away from it; to attempt to catch the ideas as they passed, and indicate them on paper by a word or phrase as rapidly as possible while making the chain of associations clear to the reader. The time allowed for each word was one minute and thirty seconds. The subject was allowed in each case to finish the word or phrase on which he was engaged at the end of the time.

In order that the results might be comparable for any two subjects it was of great importance to have words which would have approximately the same suggestiveness for both. Since the university life was the only field of experience which was sure to be common to all the subjects, a list of words connected with distinctively university institutions was selected. They were the following:

1. Registration.
2. Convocation.
3. Library.
4. Flunk.
5. Matriculation.
6. Faculty.
7. Gymnasium.
8. Football.
9. Dean.
10. Degree.

The counting of the number of associations after they were written was by no means a simple task. They were frequently written down in detached words or phrases which afforded a convenient indication of what was to be regarded as a distinct association.

But in many cases they were written in long compound phrases or sentences, and it was often difficult to decide whether a given phrase was to be regarded as one association or two. For instance, consider the phrase, "Groups of students on the campus." Is that to be regarded as one association or two? If it were written, "Groups of students—campus," it would be evidently two associations, but what is to be done with the other form? Is the difference merely one of the method of recording, or does it represent a real difference in the association process? If the latter, then "Groups of students on the campus" would have to be regarded as one definite idea, while "Groups of students—campus," would represent one idea calling up another by a fresh association. But even if this latter interpretation were psychologically the more accurate, would it be fair to count the first example as one association and the second as two? The time factor would then play a very disturbing rôle. Those subjects who

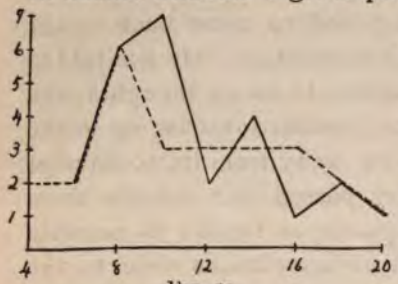

FIG. 53.

Association. Word 1.
Abscissas—number of associations.
Ordinates—number of subjects.
- - - - women; —— men.

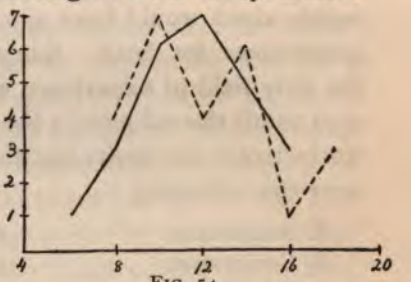

FIG. 54.

Association. Word 2.
Abscissas—number of associations.
Ordinates—number of subjects.
- - - - women; —— men.

took time to write out their associations very definitely would appear in the result as having an extremely small number of ideas within the given time. It seemed fairer, therefore, to count each clearly analyzable idea as a separate association, even in cases where its correct psychological interpretation was not that of a distinct association, but rather that of one partly organized factor in an association. In the example cited, both records would be counted as two associations. The possibility for errors and inconsistencies in counting the associations is undeniable. It was avoided as far as possible by deciding on the above criterion for separating the associations, and by going over the records several times to make sure that similar cases were always counted alike.

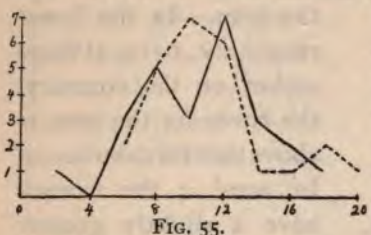

FIG. 55.

Association. Word 3.
Abscissas — number of associations.
Ordinates — number of subjects.
- - - - women; —— men.

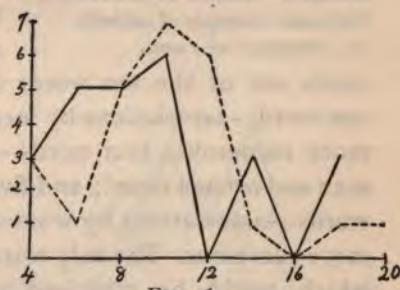

FIG. 56.

Association. Word 4.
Abscissas — number of associations.
Ordinates — number of subjects.
- - - women; —— men.

The ten curves, one for each word, showing the results of the tests, appear in Figs 53–62. In words 5, 6, 9, and 10 the women have a distinctly greater number of associations than the men. The curve for their results is seen to be, on the whole,

above that of the men in the higher ranges, *i. e.*, from ten or twelve to twenty associations; in words 5 and 9 the women's curve also extends further than that of the men. In the lower ranges, *i. e.*, 0–10, of these curves, on the contrary, the curve for the men is above that for the women. In word 4 the women have a slightly greater number of associations. In words 2, 3, 7, and 8 the two are too nearly equal to make any distinctions, while in word 1 the men have a somewhat greater number of associations. The total result out of the ten words is, therefore, as follows: one word—associations by men more numerous; four words—men and women equal; and five words—associations by women more numerous. The only word which might be criticised as possessing more suggestive power for one sex than for the other—*football* (No. 8)—did not prove to call forth more associations from men than from women.

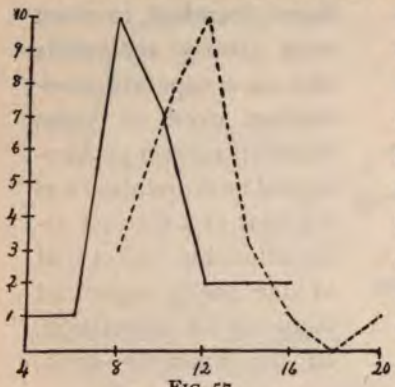

FIG. 57.

Association. Word 5.
Abscissas—number of associations.
Ordinates—number of subjects.
- - - - women; —— men.

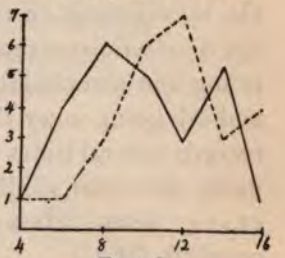

FIG. 58.

Association. Word 6.
Abscissas—number of associations.
Ordinates—number of subjects.
- - - - women; —— men.

A combination of the ten curves into one shows very distinctly the advantage

of the women on the side of number of associations. The curve was formed by a simple summation of the ten curves for women into one curve, and of the ten curves for men into another. All the cases of association series of less than two by women were grouped together, all those between two and four together, and so on for the entire series. The same proceeding was followed for the men. The resulting figure (63) shows that the curve for the men starts nearer the zero point than that of the women and keeps above it as far as eight. It crosses the women's curve at ten and falls far below it at twelve; at fourteen and sixteen it is slightly above, but falls below again at eighteen and twenty. In general, then, there are more cases of *short* association series belonging to the men than to the women, and more cases of *long* association series belonging to the women than to the men. We may conclude, therefore, that at least

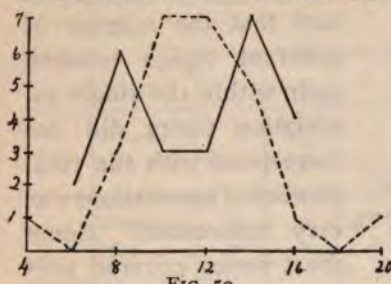

FIG. 59.

Association. Word 7.
Abscissas — number of associations.
Ordinates — number of subjects.
- - - - women; —— men.

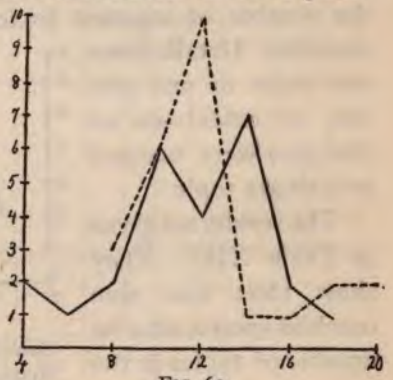

FIG. 60.

Association. Word 8.
Abscissas — number of associations.
Ordinates — number of subjects.
- - - - women; —— men.

under the conditions of the experiment, women's minds form associations more rapidly than men's.

In counting the total number of associations the fact that the number of different topics touched upon within the single association series did not correspond with the total number of associations was very noticeable. Some short series covered several entirely distinct topics, while many long series consisted merely of many details about a single topic. The associations were accordingly counted a second time with reference to the number of separate topics touched upon within the series Details about one event or one person, or reflections on one idea were counted as a single topic.

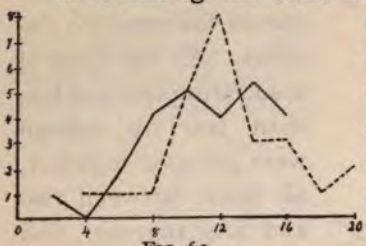

FIG. 61.

Association. Word 9.
Abscissas—number of associations.
Ordinates—number of subjects
- - women; —— men.

The results are given in Table XIII. They show that the men touched upon a smaller number of topics in the course of their associations than did the women. For every one of the ten words, there were more men than women who touched upon not more than two topics. It was also true that all the highest records were those of men, but these were few in num-

FIG. 62.

Association. Word 10.
Abscissas—number of associations.
Ordinates—number of subjects.
- - - - women; —— men.

TABLE XIII.

Association. Number of topics touched upon in the associations for each of the ten words.

Word.		Topics.							
		2	4	6	8	10	12	14	16
1	Women ..	4	13	2	3	2	1	..	..
	Men	11	5	2	5	..	1	..	1
2	Women ..	6	11	6	1	1	..	..	..
	Men	7	6	5	4	2	1	..	..
3	Women ..	9	10	4	1	1	..	..	..
	Men	10	6	5	3	1	..	..	..
4	Women ..	9	8	4	3	1	..	..	..
	Men	10	7	6	..	..	2	..	..
5	Women ..	8	8	4	3	2	..	..	..
	Men	12	5	3	3	1	..	1	..
6	Women ..	3	10	6	5	1	..	..	..
	Men	8	7	6	1	3	..	..	..
7	Women ..	9	8	3	5	..	..	..	..
	Men	12	6	2	3	..	..	2	..
8	Women ..	7	6	8	2	2	..	..	..
	Men	12	7	3	1	1	..	1	..
9	Women ..	5	6	10	2	1	1	..	..
	Men	10	5	5	3	2	..	..	..
10	Women ..	5	8	4	6	2	..	..	..
	Men	7	11	2	3	1	..	..	1

ber. The difference is shown more plainly by the curves plotted from the table (Fig. 64). These were formed like the curves for the total number of associations for the ten words (Fig. 63). The abscissas mean the number of associations, and the ordinates the number of cases in all ten words in which the series of associations touched upon the number of topics represented by the abscissas. The tendency on the part of the men to stick to one topic rather than to wander over several is shown by the far greater number of cases in which not more than two topics were touched upon in their series.

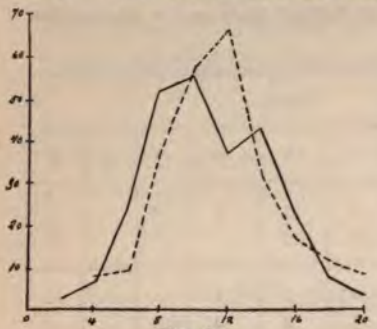

Fig. 63.

Association. Combination of the ten tests.
Abscissas—number of associations.
Ordinates—total number of occurrences of associations of each group.
- - - - women; —— men.

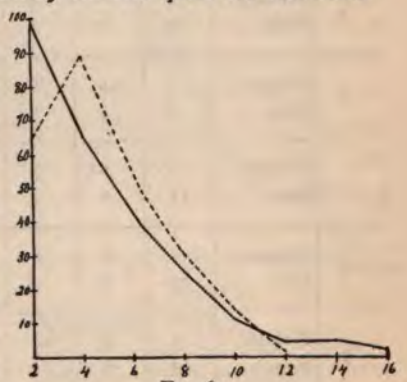

Fig. 64.

Association. Combination of ten tests.
Abscissas—number of topics touched upon.
Ordinates—total number of occurrences under each group.
- - - - women; —— men.

The outcome of the association test is, therefore, that women have a greater number of associations in a given length of time than men, and that they cover a greater number of topics. There are two factors which seem to be

of equal importance in logical processes: one is the ability to concentrate the attention on one topic, and the other is the presence of a large number and great variety of associations. The solution of problems is usually effected through some association which is not at first seen to be relevant. Concentration of attention, if it means mere sticking to one idea, is of little value in intellectual processes, while mere variety of association, without concentration of attention is equally useless. The association test indicates that men have the advantage in one of these factors and women in the other. It furnishes no ground for any statement about comparative intellectual ability.

C. INGENUITY.

The mental processes included under the general head of ingenuity are very complex and difficult of analysis. The only attempt made to measure this faculty consisted in determining the time required by different individuals for the solution of the same problem. Differences in method, important as they are for psychological analysis, were disregarded because of the extreme difficulty of determining them accurately and classifying them. The process was evaluated merely in terms of effectiveness in obtaining a solution quickly. In order to give different types of mind approximately equal advantages, five different tests of ingenuity were selected. They varied from one which required primarily perceptual quickness, to one whose solution depended chiefly on abstract reasoning. Each of the five experiments will be described and discussed separately.

The experimenter was led to regret that a more systematic attempt had not been made to record the methods of solving the problems. Although it seemed doubtful whether or not sexual differences would have been revealed by this procedure, yet it is probable that some valuable results in the technique of the solution of a problem, and in the relative effectiveness of various methods, might have been obtained. Wherever interesting differences of method were noticed they have been mentioned, not because of their bearing on the problem in hand, but because they seemed suggestive of further possible investigations of the more complex mental processes.

The chief source of error, both in the ingenuity tests and in the subsequent tests on general information, was that since the same problems were used for all, some individuals might have been told what they were by those who had already been subjected to the experiment. All the precautions possible were taken against this. The subjects were requested not to tell what the problems were, and were asked whether or not they had been told what they were before the problems were given. There were very few cases where there was any suspicion on the part of the experimenter of any previous knowledge. Even granting that there is an unknown error in the results due to this cause, they are fairer than they would have been if different problems had been used for different subjects, because of the impossibility of measuring the difficulty of a problem exactly.

The first ingenuity test was one selected because its solution depended chiefly on skill in manipulating and transforming a visual perception, although it was

not solved through perception by all subjects. Fifteen matches were laid on the table in such a way that they formed five squares in the relative position shown in Fig. 65.

The subject was then asked if he had ever seen the figure before or knew its purpose. One of the fifty — a woman — had seen it before, but had forgotten its purpose. She found the solution in ten seconds, but since she was doubtless assisted by her previous acquaintance with the figure, her record is not included in the curve. The others, upon stating that they had no previous knowledge of the figure or its purpose, were told that the problem was to remove three matches from it in such a way that three perfect squares only remained; in other words, to remove three matches in such a way that every match remaining on the table after the three were removed should be a part of a perfect square. No rearranging of the remaining matches was allowed. The subjects were all given exactly the same directions, and were left entirely free to use any method they chose. Removing matches on trial was permitted. Time was counted from the moment the conditions were understood.

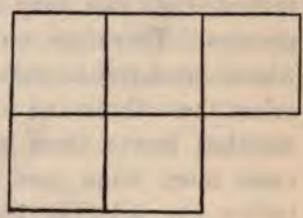

FIG. 65.

Three different methods of solution were employed. The first consisted in trying, either actually or in imagination, the effect of removing various combinations of three matches; the second in attacking the problem from the standpoint of the solution and trying to discover what combination of three squares

would leave three superfluous matches; the third in a logical process like the following: There are fifteen matches in the figure; removing three leaves twelve. The twelve remaining matches must form three squares, showing that the three squares must be detached, *i. e.*, can have no side common to any two squares. There are only three squares in the figure which conform to these conditions. It is easy to select these three and to see that the removal of three matches leaves them alone on the table. In most cases more than one of these methods were tried before the solution was obtained. In general the second method was quickest, but in the case of the most rapid solutions, it was usually difficult for the subject to tell what method he had used; all he could say was that he saw, almost as soon as he looked at the figure, which were the required matches. The logical solution was used in only a few cases. It took from five to fifteen minutes. The long times were filled out by a more or less aimless trying of various combinations of three matches.

The curves showing the result of the first ingenuity test are given in Fig. 66. The women are, as a whole, quicker. The advantage of the women in this case is probably a little greater than is represented in the curves. One woman who was very quick at such problems was excluded from the tabulation of results because she was under the impression that she had seen the puzzle before. The woman who is recorded as "failed" was one of the first people tested. She gave up after working fifteen minutes. (In subsequent cases the subjects were required to work until the solution was obtained.) However, even as the curve

stands, there is a distinct advantage on the side of the women. There are more of them in the range of short times, and there are five men who took longer than the slowest woman.

The second ingenuity test was designed to call a pure process of reasoning into play. It consisted of a puzzling mathematical problem, perfectly simple in the computations involved but demanding a somewhat

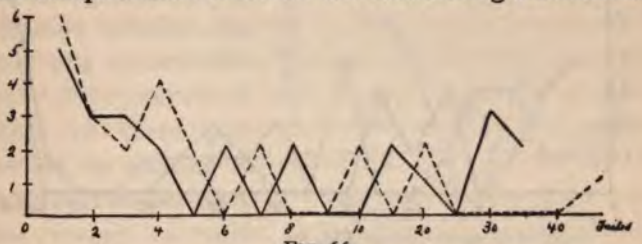

FIG. 66.

Ingenuity. First test.
Abscissas — time in minutes.
Ordinates — number of subjects.
- - - - women; —— men.

complicated process of reasoning for its solution — a problem in which it was easy to become confused unless all the factors were sharply separated and clearly grasped. The problem was handed written to the subject. He was told that it involved no difficult computations. The process was timed from the moment the problem had been read through. A failure was recorded only in cases in which the subject had worked from forty-five minutes to an hour, and was completely hopeless of getting any solution. The problem was the following: "A man swimming in a river finds that he can swim three times as fast down stream as up stream. The river flows at the rate of a mile an hour. Find his rate of swimming in still

water." Any solution which could be explained was accepted. A mere stumbling upon the correct answer was not called a solution.

The curves of results for the second test (Fig. 67) show no marked difference between the men and the women in quickness of calculation. On an average the men have somewhat the advantage. Two of the men

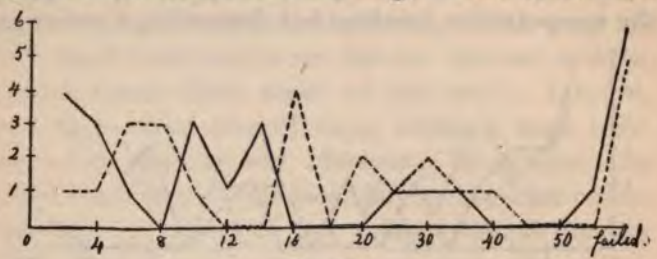

FIG. 67.

Ingenuity. Second test.
Abscissas — time in minutes.
Ordinates — number of subjects.
- - - - women; —— men.

with very good records had been teaching mathematics within a year, while none of the women were primarily concerned with it. Taking this fact into consideration, the difference between the two curves is insignificant.

The third problem involved to some extent both perceptual quickness and reasoning. The apparatus consisted of a checker-board, composed of red and yellow squares, and eight men. The board had eight squares, four of each color on each side, like an ordinary checker-board. The problem was to place the eight men on the board in such a way that no two were on the same straight line of squares, either perpendicularly, horizontally, or diagonally. Both red and yellow

squares could be used. The problem is far too complicated to be solved by inspection, nor can it be reasoned out in detail. The process in solving it consisted in adopting some general method, and trying it, modifying it if necessary, until the proper combination was hit upon. There was one method which gave a logical certainty of some solution, but only one or two subjects discovered it. Most of them proceeded by starting at some part of the board and trying to work systematically from that point. If that failed, another portion was taken as starting-point and the trial made again. Some few placed all eight men in a row along one side of the board, and worked by moving seven of them out from this position, varying the placing until the conditions were fulfilled. In almost all cases the subject felt that the solution, when obtained, was largely a matter of chance. He had simply stumbled upon the right combination, rather than really solved a problem. Very few of them could have reproduced the solution after the men were removed from the board. However, the problem certainly required original method, quickness in seeing complicated forms, and perseverance.

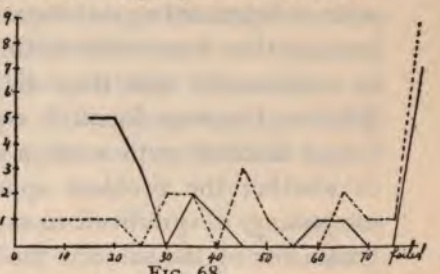

FIG. 68.

Ingenuity. Third test.
Abscissas — time in minutes.
Ordinates — number of subjects.
- - - - women; —— men.

In this test the men show themselves decidedly superior to the women (Fig. 68). There were two women who were quicker than any of the men, but there

were also two more women than men who failed. The superiority of the men is shown in the great majority of them in the region from fifteen to thirty minutes. It is very difficult to evaluate this difference, because of the indefinite nature of the problem. Most of the women expressed a great distaste for all such problems, because they were uninteresting. Many of them were so uninterested that they did not really work at it. Whether the men found it equally uninteresting, but forced themselves to work in spite of lack of interest, or whether the problem appealed to them as more interesting, it is difficult to say. From the voluntary comments of the subjects the latter hypothesis seems more probable, but in this case we are confronted by the further question why such a problem should have more interest for men than for women. The test may point to a greater interest on the part of men in a problem, merely as a problem, regardless of any possible usefulness, or any further application.

The fourth trial of ingenuity was a mechanical problem. The subject was required to find out the method of operating the apparatus used for determining the light threshold described above on p. 76.

The test was always made shortly after the determination of the light threshold, when there was usually a spontaneous interest in the apparatus. The necessity for uniformity in the time of the stimulus was explained, and the subject was told that his problem was to find out, first, how a constant length for all exposures of light was secured automatically, and second, how the absolute intensity of the light was varied. He was told that he might do anything he pleased with the apparatus, except take out screws, which would not be necessary to discover its workings.

The apparatus was particularly favorable for a comparative test, because it was so entirely unfamiliar to all the subjects. The mechanical principles involved in it were all very elementary. The difficulty was to find out how the various parts worked together. Since the apparatus was so unique, acquaintance with other mechanisms was of as little assistance as possible, although unquestionably a knowledge of mechanics in general is of assistance in solving any particular mechanical problem, however unlike previous ones it may be.

Two difficulties were experienced by all the subjects in this problem. The first was in making the connection between the metal ball and the inclined trough. The ball was not found in the trough, but lying on the table by the apparatus, either in an open box or in the stop at the foot of the padded incline. The second difficulty, which was still more serious, was to discover that the ball could be released and the screen opened by a single movement. The fact that the ball would close the screen was found out very quickly. The method of regulating the absolute intensity of the light gave but little trouble.

Only twenty-one women and twenty-two men are recorded in the curves for this test, because it was not given to the first subjects on whom the experiments were performed. The apparatus was explained to them at their request. When later the decision to use it for an ingenuity test was made it was of course impossible to apply the test to these subjects.

In the fourth test the men have a somewhat better record on the whole than the women (Fig. 69), although the difference is not marked. There is a considerable majority of the men in the region under fifteen

minutes, but they are also somewhat in excess at the other end of the curve. None of the women failed to get a solution in an hour, while two men worked from an hour and a quarter to an hour and a half and failed.

The fifth ingenuity experiment was also the solution of a mechanical problem. The subject was given a wooden model of a very simple combination lock. He was told that it was a model of an object with the use of which he was perfectly familiar, although the form was unusual, and that he was to find out what it was and how it worked He was told whether or not he was correct when he thought he knew its use. Most of the subjects could tell what it was before they discovered how it worked, although in a few cases the reverse was true.

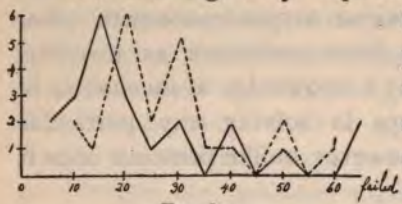

FIG. 69.

Ingenuity. Fourth test.
Abscissas — time in minutes.
Ordinates — number of subjects.
- - - - women; —— men.

A diagram of the lock is given in Fig. 70. The inside of the lock is shown in its locked position, *i. e.*, with the bolt A out. The bolt was held in place by a rod at B, which passed through a long, narrow opening, leaving the bolt free to move back and forth the distance of the opening, and also up and down about the rod as axis, from the top of the lock to the bottom. A spring, C, passed from the inner end of the bolt A to a rod fastened to the wall of the lock at D. E and F represent pegs which moved freely about their axes. Handles from these pegs projected about one inch through the wall of the lock. To unlock it, the peg

E was first turned so as to raise the bolt toward F. When the bolt was at its highest point the catch, G, was opposite the peg F. When F was then turned so that its thin edge pointed to the back of the lock, it carried the bolt with it, and braced it inside of the lock so that none of it projected. The lock was then unlocked. To lock it, it was only necessary to turn the peg F back to the position shown in the figure, when the bolt, through the action of the spring C, at once flew back to its original position. The lock was always given to the subject in its locked position as shown in the sketch.

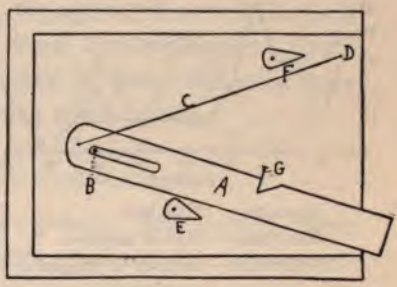

FIG. 70.

Ingenuity. Apparatus used in fifth test.

The chief difficulty experienced in this test was in discovering that the bolt would move in and out, as well as up and down. The up-and-down motion was apparent as soon as the pegs were moved, but the opening in the bolt on which it moved in and out was so far back that it could not be seen by looking in at the open end of the lock, and the subjects were not allowed to take it apart. In some cases the in-and-out movement was discovered by an accidental pressing on the bolt, sometimes it occurred to the subject to try that movement purposely, and sometimes it was found by experimenting with the peg F and its relation to the catch G. After the in-and-out motion was once discovered the solution usually came quickly. At first most of the subjects explained it on

the basis of the up-and-down movement as a latch, and worked out the other solution only when they were told that it was not a latch.

The results show a very evident advantage on the side of the men. The majority of them solved the problem in less than twelve minutes, while the majority of the women took more than twelve minutes. Two women failed entirely, while all the men worked out the solution in forty-five minutes or less. The difference was no doubt partly due to the fact that most of the men were familiar with the construction of locks in general (although none of them knew exactly this form), while the women had had much less experience with locks of any sort.

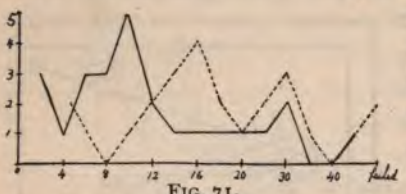

FIG. 71.

Ingenuity. Fifth test.
Abscissas — time in minutes.
Ordinates — number of subjects.
---- women; —— men.

To sum up the results of the ingenuity tests, they show that, on the whole, the men have a decided advantage. They were much superior to the women in two tests (the third and the fifth), somewhat superior in one (the fourth), equal in one (the second), and inferior in one (the first). There are several indications that special education plays some part in these results. Two of the problems in solving which the men proved superior to the women, viz., those of the lock and the visual apparatus, were in the realm of mechanics, with which men are by education more familiar than women. In the lock problem the men's superiority is marked, while in the visual-apparatus

problem it is only slight. The latter problem, dealing as it did with a unique machine, was one in which previous experience with mechanical contrivances would be of comparatively little assistance. Experience with locks, however, would assist materially in solving the lock problem, though the form of the lock was unfamiliar. Of the three non-mechanical problems, the women were better in one, the men were better in one, and they were equal in one.

D. GENERAL INFORMATION.

The questions to test general information were selected as a test for college students, not as a representative set of questions for intelligent people in general. The correct answers were facts that a college student of the third or fourth year could fairly be expected to know. The majority of them were facts that the average college student must have known at some time during his career. It was sought to make the questions perfectly fair and representative; there were no catch questions. In order to make the evaluation of the results as exact as possible, questions of fact only were asked. The answers are definitely either right or wrong; they can be marked with very little variation due to the personal equation. An exact evaluation of questions of theory or opinion is much more difficult.

The questions were handed to the subject written, and he was given all the time he wished to answer them. They were as follows:

1. Name two writers of English who wrote before Shakespeare; give the title of one work of each, and tell whether it was poetry or prose.

2. Give approximately the dates of the period during which Shakespeare wrote.
3. To what nation and what period does each of the following writers belong: Pope, Racine, Schiller, Coleridge, Balzac, Dryden, Petrarch, Heine, Browning, Ibsen?
4. Name one work of each of the following writers: Tolstoi, Charlotte Brontë, Macaulay, Victor Hugo, Nathaniel Hawthorne.
5. Who wrote the following works: *Tom Jones, Cyrano de Bergerac, Two Gentlemen of Verona, The Excursion, Pride and Prejudice, Richard Feverel, Childe Harold, Adam Bede, The Vicar of Wakefield, The Newcomes?*
6. Name the great subdivisions of the Aryan race.
7. Name the nations occupying the Tigris and Euphrates valley previous to the time of the Roman empire.
8. Name (*a*) two famous lawgivers of ancient Greece, and (*b*) three Grecian cities which, at different times, held supremacy over Greece.
9. (*a*) When did the French Revolution occur?
   (*b*) Name three men who were prominent in French politics during the five years subsequent to the beginning of the Revolution.
10. (*a*) When did the Roman republic cease?
    (*b*) What form of government followed the republic?
    (*c*) Who brought about the change?
11. (*a*) What was the Missouri Compromise?
    (*b*) What is its date, approximately?
12. Is hypnotism an established scientific fact, or is it fraud and superstition?
13. How does the binomial theorem lessen labor in mathematics?
14. Solve this equation for x: $5x^2-3x=2$.
15. What is (*a*) a sine? (*b*) a tangent?
16. (*a*) What are the fundamental laws of motion?
    (*b*) Who first formulated them?
17. What does it mean to say that the specific gravity of a body is four?
18. What is the principle on which the telephone works?
19. Is the energy furnished by an electric battery created in the battery? If not, where does it come from?

20. Give the chemical formula for water, and explain its meaning.
21. What happens to the substance of a piece of wood when it is burned? Is any of it destroyed?
22. Are there any cases of spontaneous generation among living organisms? If so, where?
23. What is the nature of the simplest type of animal known?
24. Name the departments of biology, and the other branches which have contributed most to establish the truth of the theory of evolution.
25. For what were the following men noted, and in what century did they live: Weissmann, Socrates, Esterhazy, John Stuart Mill, Bach, Charlemagne, Nebuchadnezzar, Kant, Pericles, Bacon, Rameses II., Goethe, Alfred the Great, Dante, Alexander, Kepler, Richelieu, Edmund Spenser, Galileo, Herbert Spencer?

Even in questions as definite as these some difficulties arise in grading. For instance, where approximate dates are asked for, how close an approximation shall be demanded? In each of these cases a more or less arbitrary standard was adopted. For instance, if the dates given for the period during which Shakespeare's plays were written included the greater part of the correct period, the answer was given full credit; if they included a small part only, part credit was allowed. If they fell entirely out of the correct period, no credit was given. Answers to the third question were considered correct as to date if the correct century was given for each of the writers named. The latter part of the eighteenth century was considered a correct answer as to the date of the French Revolution. Dates within fifty years, on either side, of the end of the Roman republic and within ten years of the Missouri Compromise were called correct answers as to those events. The last question was

considered correctly answered as to dates if the century given for each man mentioned were within one hundred years, on either side, of the correct period, except in the case of men who lived in the eighteenth or nineteenth century, where the correct century was required in the answer. In the very early dates, still more leeway than a century was given.

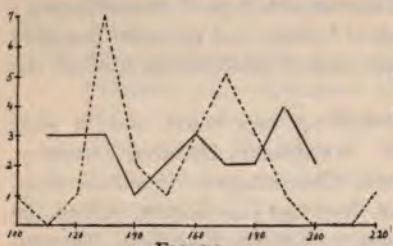

FIG. 72.

General information. Entire series of questions. Highest possible grade, 250.

Abscissas — grade of the papers.
Ordinates — number of subjects.
- - - - women; —— men.

Before giving the results of this test, one very evident source of error must be mentioned, which was also met with in the ingenuity tests. The same set of questions was used for the entire series of subjects, and there was always the possibility that later subjects had been told some of the questions by previous ones. Each subject was requested not to talk about the questions to other students, because the same set of questions was to be used for all. Each subject was asked before he was given the questions whether or not he had been told anything about them. Aside from these precautions, there was nothing to be done except trust to the honesty of the subject. Any accurate evaluation of the test would have been impossible if different sets of questions had been used, because no two sets of questions of exactly equal difficulty could be made out. Just how large a part a previous knowledge of the questions really played in the results, it is of course impossible to say. The impression of

the experimenter was that it was very small. There were only one or two cases where there was even a suspicion of such knowledge.

The twenty-five questions fall into the following classes:

English literature (five questions).
History (six questions).
Physics (four questions).
Mathematics (three questions).
Biology (three questions).
Chemistry (two questions).
Psychology (one question).
General (one question).

The results of the tests will be given both for the entire series and for the separate divisions. The answers were graded on a basis of 10 for each question. The highest possible grade for the entire series is therefore 250; that for each division is given below the appropriate diagram of results.

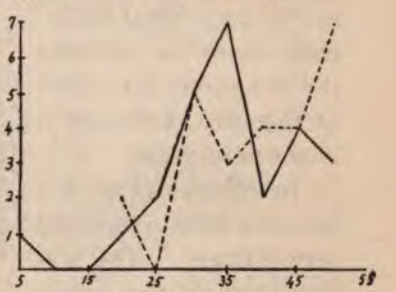

FIG. 73.

General information. Questions on English literature. Highest possible grade, 50.
Abscissas — grade of the papers.
Ordinates — number of subjects.
- - - - women; —— men.

The two curves for the total examination (Fig. 72), although different, do not differ in such a way that we may call one better than the other. Both the extreme records, 100 and 220, are those of women; but on the other hand the men are more numerous than the women at both extremes. There are six men and only two women under 120, and also

six men and two women over 180. The curves, on the whole, coincide remarkably. Both center around 160, where each stands at three. Each one has twelve below and ten above 160.

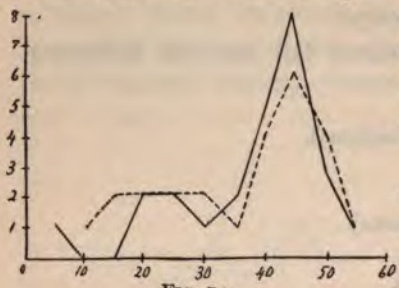

FIG. 74.

General information. Questions on history. Highest possible grade, 60.
Abscissas — grade of the papers.
Ordinates — number of subjects.
- - - - women; —— men.

The curves representing the grades in English literature (Fig. 73) show a decided advantage on the side of the women. From thirty-five down the curve for the men is above, while from thirty-five up, that of the women is above.

The results of the examination on history appear in Fig. 74. What difference there is between the two curves is in favor of the men, although it is not very great.

In physics (Fig. 75) the men have a decided advantage. The extremes of the two curves are the same, and the women are slightly more numerous in the region of the best records; but the general course of the men's curve is better than that of the women's. The majority of the women fall below fifteen, the majority of the men above.

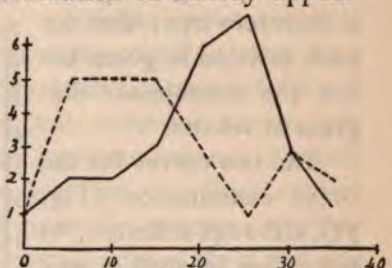

FIG. 75.

General information. Questions on physics. Highest possible grade, 40.
Abscissas — grade of the papers.
Ordinates — number of subjects.
- - - - women; —— men.

The two curves for the examination on mathematics (Fig. 76) correspond closely. What difference there is, is in favor of the women. There are more men than women in the lower ranges, and more women than men in the upper.

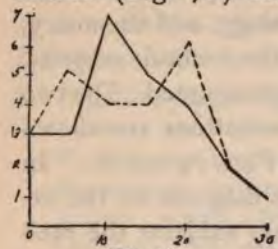

FIG. 76.

General information. Questions on mathematics. Highest possible grade, 30.
Abscissas — grade of the papers.
Ordinates — number of subjects.
- - - - women; —— men.

In biology (Fig. 77) we find the men in excess at both the good and bad extremes. The general course of the curves, however, shows a somewhat higher average in the women's record.

The questions in chemistry were both so simple that the answers were almost all correct. Eighteen women and seventeen men were graded at ten on both questions.

In the question on hypnotism the men have a better record than the women. The men all answered correctly. Four women failed on the question.

The results of the examination on question 25 appear in Fig. 78. Here again the men are in excess at both extremes. It is impossible to call either curve better, on the whole.

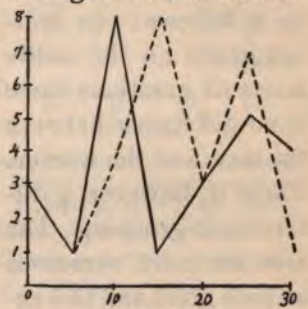

FIG. 77.

General information. Questions on biology. Highest possible grade, 30.
Abscissas — grade of papers.
Ordinates — number of subjects.
- - - - women; —— men.

To assist further in the analysis of the results of

the general-information tests, the grades in English literature and history, as the literary subjects, and those in physics, mathematics, biology, and chemistry, as the scientific subjects, were summed. The two summations are shown in Figs. 79 and 80. In the diagram for the literary subjects the men are more numerous in the middle ranges and the women in the higher, while in the diagram for the scientific subjects the reverse is the case.

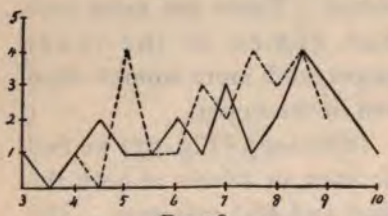

FIG. 78.

General information. Question 25. Highest possible grade, 10.
Abscissas — grade of papers.
Ordinates — number of subjects.
- - - - women; —— men.

The results of the series of tests on general information may be summed up as follows: In average grade on the entire series of questions there is no difference between the men and the women. There is, however, a difference in grouping. The men are more numerous at both good and bad extremes than the women, and the women more numerous than the men in the middle ranges. The women stand better than the men in the literary subjects, and not so well in the scientific. This does not mean that the women

FIG. 79.

General information. Summation of grades in the literary subjects. Highest possible grade, 110.
Abscissas — grade of papers.
Ordinates — number of subjects.
- - - - women; —— men.

were superior in both the literary subjects nor that the men were superior in all the scientific. The relation of the sexes in the separate subjects was as follows:

English literature : women much superior.
History : men a little superior.
Physics : men much superior.
Mathematics : women very slightly superior.
Biology : women a little superior.
Chemistry : both sexes equal.

In the results of the tests on general information, as in those on ingenuity, special training is unquestionably a factor. As appears from Table XXVII, far more women than men were interested in English literature. Although the women were as interested in science as the men, probably the stress of their work had fallen more on literary than on scientific studies. Many of the women were preparing to be teachers, and had, therefore, from practical considerations devoted themselves primarily to those subjects in which the openings for women are most numerous, viz., literary subjects. Many of the men, on the other hand, intended to be physicians, and hence were laying the stress of their work on scientific studies. The slight superiority of the men in history is probably due to the presence of several students who were preparing for a law course.

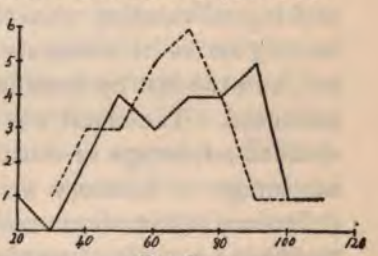

FIG. 80.

General information. Summation of grades in the scientific subjects. Highest possible grade, 120.
Abscissas — grade of papers.
Ordinates — number of subjects.
---- women; —— men.

SUMMARY OF OTHER EXPERIMENTAL WORK ON INTELLECTUAL PROCESSES.

There have been a number of researches on the comparative memory of the sexes, although none of the others have required memorizing or measured retentiveness. The other tests have all followed the method of making a single presentation of some series of stimuli and requiring the subject to reproduce it. The power of memory was then measured by the accuracy of the reproduction. Tests on university students have been made at Columbia University (82) and at the University of Wisconsin, the latter by Jastrow (35). At Columbia University visual, auditory, and logical memory were tested; the first two by presenting series of numerals through the eye and the ear, and the last by reading aloud a passage to be reproduced. The result was to show that women had a decided advantage in visual memory, men a doubtful advantage in auditory memory, while there was no difference in logical memory. Jastrow's method was to display a series of words one by one, requiring the subject to write the first association which occurred to him. Two days later the subject was asked to write the original list again from memory. In this test women made a better record than men. It was afterward performed on high-school students with the same result. Stern (76a) has made a few tests tending to show that the memory of women for the details of pictures is completer than that of men, but that they add in recollection more of imaginary material than do men. Bolton (9) tested auditory memory in school children, both in the high school and in the grade schools, by the method of reading

aloud a series of numerals, which were then reproduced. He finds the girls decidedly better than the boys. Shaw (75) employed the method of requiring school children to reproduce a story which had been read to them, and again the girls made the better record. Netschajeff (60) experimented on school children of St. Petersburg, varying from nine to eighteen years in age. He tested memory for objects, sounds, numbers, and various kinds of words. His general result is that, with slight exceptions, girls excel boys in power to recall. Very much the same series of tests was performed by Lobsien (48) on school children of Kiel between the ages of nine and fourteen and a half. His results are formulated with reference both to the number of impressions reproduced and to the correctness of the order in which they were reproduced. He finds that the girls excel the boys in both respects. Ebbinghaus (22) used memory as one of his methods of testing mental ability. He stands alone in finding girls inferior to boys up to the age of eleven or twelve years. The fact that the boys and girls he tested were being educated in different kinds of schools (*Gymnasium* and *Mädchenschule*) may account for this discrepancy. The results of former experiments thus agree almost unanimously with the present series in showing better memory in females than in males.

Two investigations other than the present are on record in which the attempt has been made to obtain a statement of the comparative rapidity of the association process in men and women. Jastrow (34) took the time required to write one hundred words as rapidly as possible. He found no difference in the

time required by men and women ; but as he himself says, his method of measurement was rough. The second association test referred to was made at Columbia University (82). It consisted in requiring the subject to write the first association to each of nine words. The words were given the subject printed on a card. The entire time of the process was taken. The men proved to be more rapid than the women. Neither of these results accords with those of the present test, which show the women to be somewhat more rapid. If what is sought is a measurement of the normal rapidity in passing from one idea to the next when the process is made as natural as possible, the form of test employed in this series seems better fitted to give the required value than the two just described. The process of merely observing and noting down the thought sequence as it occurs from a given starting-point seems less artificial than that of writing down one hundred different words, or of writing the first association to a given word. The writer is therefore inclined to put more faith in the results of this test than in those of the others.

Qualitative, as distinguished from quantitative, comparisons of the association faculty in men and women have been made experimentally by Jastrow (34, 35, 36, 37) and by Miss Calkins (13) and her students (61). Two methods were employed by each. The first was to require the subject to write one hundred different words as rapidly as possible. Jastrow finds that men furnish a greater variety of words and a greater number of unique ones than women. Miss Calkins, on the contrary, finds the variety of words furnished by women about equal to

that of men, and their number of unique words greater than that of men. The second method consisted in requiring the first association to each of a list of given words. Neither investigator discovered any difference by this method. They agree in finding some classes of words mentioned more frequently by one sex than by the other, such as food-stuffs by women. But as both Miss Calkins (13) and Miss Tanner (79) have pointed out, this fact points not to original sexual difference in type of mental activity, but to difference of training and surroundings from childhood on.

There are no previous tests on ingenuity and general information with which those above recorded may be compared. It is well known that in school work girls have better records on the whole than boys (55, p. 1045). But the general average of school work is not comparable to the results of our test on general information. The former takes account of the way in which the lessons assigned are learned, the latter of the amount of definite information which the individual has at hand when it is suddenly called for.

There are a few other investigations which have a more or less remote bearing on the intellectual tests. Lindley (47), investigating puzzle interests, says that he discovered no difference in the age at which the various puzzle interests develop in the two sexes. He attributes this failure to the small number of individuals investigated. Dearborn (19), studying the imagination by means of ink blots, found no difference between the sexes. Minot (58), found greater uniformity in women's diagrams than in men's. Miss Calkins (12), investigating the mathematical consciousness,

found from answers to a questionnaire that men are more likely to reason out a mathematical demonstration, and less likely to memorize it, than are women. This is not in agreement with the present tests, which show that the women as a whole have an equal capacity with the men for furnishing an original solution of a mathematical problem when it is called for unexpectedly. Ebbinghaus (22), and Bellei (8), both made tests on school children which were intended to measure intellectual ability. The former used the methods of mental arithmetic, memory, and what he calls a combination method, which consisted in requiring the child to fill in the omissions in a text which had been prepared with some syllables or letters omitted. The rapidity and accuracy with which this could be done was regarded as a measure of mental ability. The latter used the first and third of the methods just described. Ebbinghaus found the boys superior to the girls up to the age of fifteen, when the girls were somewhat superior. Bellei's results do not agree with Ebbinghaus's. His experiments were confined to children of a single class in school having an average age of eleven years. He finds the girls superior to the boys.

GENERAL SUMMARY OF EXPERIMENTS ON INTELLECTUAL FACULTIES.

It is well established that women have better memories than men; they memorize more quickly and retain as well. The results of the various experiments on association do not agree as to either quantitative or qualitative differences of sex. The most trustworthy evidence goes to show that the process of association

is somewhat more rapid in women than in men. As to qualitative differences, none of the methods employed seems to have thrown, or to be capable of throwing, any real light on this question. The experiments which have been performed to determine comparative ingenuity show the men superior to the women. There are indications, however, that mechanical training, which boys unquestionably receive to a greater extent than do girls, is an important factor in this result. The question whether the more extensive mechanical education of boys is not to be accounted for by their greater natural ingenuity will be discussed later. In total amount of general information there is no difference between men and women who have taken the same course of education. The women are somewhat the better informed in literary and the men in scientific subjects, but this is probably due to selection of studies and not to sex.

CHAPTER VIII.

AFFECTIVE PROCESSES.

THE affective processes were investigated from two points of view:

A. The physiological expression of affective processes as revealed in circulation and respiration.

B. The introspective account of affective processes given in response to questions on personality of the following classes:
   1. Questions on age, health, and nationality.
   2. Questions on sensory experiences.
   3. Questions on methods of rest and recreation.
   4. Questions on the individual aspects of personality.
   5. Questions on the social aspects of personality.
   6. Questions on intellectual interests, methods of work, and beliefs.

A. THE PHYSIOLOGICAL EXPRESSION OF AFFECTIVE PROCESSES AS REVEALED IN CIRCULATION AND RESPIRATION.

For investigating the changes in circulation and breathing in response to the affective processes Hallion and Comte's air plethysmograph (32) and Bert's rubber-capped metal respirator were used respectively. These instruments were used simultaneously, writing side by side on a smoked drum.

The object of the experiment was not explained to the subject. He was directed to sit still and keep his eyes shut. A normal curve was first taken to show the characteristic reaction of the individual in a state of repose. When this had been obtained vari-

ous stimuli were applied. Agreeable and disagreeable odors were given him to smell; he was touched on the face with a piece of cold metal; a loud sound was produced by dropping a heavy object on the floor; his hand was pricked with a pin; and to show the effect of mental application he was given problems in addition and multiplication to solve. The curve was watched constantly, and if any marked changes occured in it during the interval between stimulations, the subject was told to remember what he was thinking about at that time and report later.

In the belief that the significant features of the changes in pulse and breathing were to be sought rather in the amount of the change than in its form or direction (2) the results were formulated on the basis of the violence of the changes in the plethysmograph and the respirator curves, due either to spontaneous emotion, or to the stimuli applied. Table XIV gives the results:

TABLE XIV.

Degree of change in respiration and circulation in response to affective changes.

	Changes.		
	Slight.	Medium.	Violent.
Women	11	8	6
Men[1]	7	6	10

The table shows a greater proportion of men than women with violent physiological changes, and a greater proportion of women than men with slight

[1] But twenty-three men appear in this table because two records were accidentally destroyed.

changes. If, as is supposed, the amount of change in the curve runs parallel with the degree of emotional disturbance, the result means that the men had slightly more intense affective experiences than the women — a conclusion decidedly opposed to the popular opinion on this subject.

B. THE INTROSPECTIVE ACCOUNT OF AFFECTIVE PROCESSES GIVEN IN RESPONSE TO QUESTIONS ON PERSONALITY.

The series of questions on personality was designed to cover all questions of interest with regard to an individual which do not lend themselves to experimental treatment, or at least which could not be treated experimentally in the present series of tests. The questions centered chiefly upon the affective consciousness — upon temperament and disposition, likes and dislikes, and interest. They included also whatever questions of fact with regard to the individual's history seemed important.

The evaluation of the answers to the questions which dealt merely with facts of individual history presents no serious difficulty. The answers to questions on the nature of the individual's affective consciousness, on the other hand, are extremely difficult to evaluate. The difficulty is the one involved in all questionnaires. There are at least two important sources of error which the experimenter has no means of controlling or measuring. The first is the fact that many individuals have not the skill to interpret carefully and accurately if they will; the second is the fact that many individuals will not be, or cannot be, perfectly honest in answering questions on personality. What we are sure of getting in answer to such questions, is

not so much true statements with regard to the personality of the individual, as the individual's reaction toward the question asked. The answer will approach the truth in proportion as the individual is skilled in introspection and honestly endeavors to tell the truth. How far these conditions were fulfilled in the present case it is impossible to say; but it may be said that the conditions of the present questionnaire were as favorable as possible for their fulfilment. The individuals questioned had all had some training in psychology and were therefore more skilled than average persons in introspection. They had all voluntarily lent themselves to the test out of interest in it, and would for that reason be likely to endeavor to be honest. Their judgment was entirely unbiased by any knowledge of the ultimate purpose of the test. The questions were asked one by one by the experimenter and answered orally by the subject. Each question could thus be explained whenever necessary, and the answer discussed. The general impression of the experimenter was that the subjects were really interested in the questions and tried to give honest answers.

The questions asked dealt with the following subjects: (1) age, health, and nationality; (2) sensory experiences; (3) methods of rest and recreation; (4) individual aspects of personality; (5) social aspects of personality; and (6) intellectual interests, methods of work, and beliefs.

1. *Questions on age, health, and nationality.*—The first set of questions on personality was designed to bring out the degree of homogeneity of the material for this investigation. The questions were as follows:

1. What is your age?

2. What is the state of your health, poor, medium, good, or excellent?

3. Are there any physical abnormalities of your sense organs of which you are aware?

4. Do you consider yourself of a nervous temperament?

5. What is your own nationality and that of your parents? Of what nationality were your ancestors?

The ages of the subjects are represented in the curves of Fig. 81. The age curves for men and women coincide very closely, twenty-two of each falling between the limits of nineteen and twenty-three years. Three of each sex were twenty-five years old or more. Both curves culminate at twenty-one years.

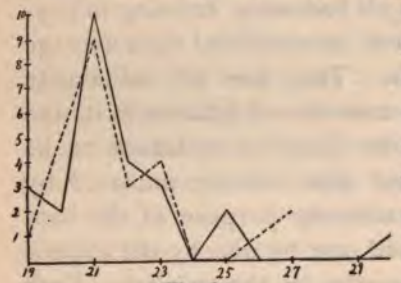

Fig. 81.

Age of the subjects.
Abscissas — ages.
Ordinates — number of subjects.
- - - - women; —— men.

The answers to the question on health are represented in Table XV, which shows four more women than men in the poor and medium sections, and four more men than women in the good and excellent sections. There were, however, more women than men who graded

TABLE XV.

Health of the subjects.

	Poor.	Medium.	Good.	Excellent.
Women.....	3	4	4	14
Men.....	..	3	12	10

themselves as having exceptionally good health. We find the women therefore more numerous at both extremes of health and the men more numerous in the middle range. The total balance would incline toward better health for the men.

The number of physical abnormalities of the sense organs reported is summed in Table XVI. The records of the two sexes coincide almost exactly.

TABLE XVI.

Physical abnormalities of the sense organs of the subjects.

	Eye.	Ear.	Nose.	None.
Women	6	4	3	15
Men	5	4	3	15

Table XVII shows the way in which the question on nervousness was answered. Here again the records of the two sexes coincide too closely to indicate any difference between them in this respect.

TABLE XVII.

Degree of nervousness of the subjects.

	No.	Slightly.	Yes.
Women	9	7	9
Men	10	5	10

All of the subjects were of American birth. Two of the men were Canadians, but all of the other subjects were born in the United States. The men showed a larger percentage of foreign parentage than the women. Both parents were natives of the United

States in the case of twenty of the women and sixteen of the men. The birthplace of the parents in the remaining cases is shown in Table XVIII.

TABLE XVIII.

Nativity of the parents of the subjects.

Women.	Men.	Nativity of Parents.
20	16	Both parents born in United States.
..	2	One parent born in United States, the other in England.
1	..	One parent born in United States, the other in Ireland.
1	..	One parent born in United States, the other in the West Indies.
..	2	Both parents born in Canada.
1	..	One parent born in England, the other in Canada.
..	1	One parent born in England, the other in Wales.
..	2	Both parents born in Germany.
1	..	Both parents born in German Poland.
..	1	One parent born in Germany, the other in Switzerland.
..	1	Both parents born in Austria.
1	..	Both parents born in Russia.

The nationality of the subjects' ancestors appears in Table XIX. One man and one woman did not know anything about their ancestors previous to their settlement in America, and hence could not answer the question as to their nationality. Many of the other subjects seemed doubtful on this question. The report is therefore incomplete and probably incorrect in some respects. Still, it serves as some indication of the races most largely represented.

It appears from the table that the ancestry of the great majority of the subjects, both men and women, was English, Welsh, Scotch, or Irish. After the British nationalities, in order of representation in the table,

TABLE XIX.

Ancestry of the subjects.

	English.	Scotch.	Irish.	Welsh.	French.	German.	Austrian.	Dutch.	Swiss.	Italian.	Spanish.	Russian.	Jewish.
Women.....	14	9	5	4	5	8	..	1	..	..	1	1	..
Men.....	12	10	5	2	7	7	1	3	1	1	..	1	1

comes the German, and after that the French. Other nationalities are represented only in scattered instances.

The general result of the questions on age, health, and nationality was to show a high degree of uniformity in these respects among all the subjects. Since these are all factors which might, if they differed widely, be held accountable for differences discovered between the sexes, the fact that in respect to them the records of the men and the women examined coincide so closely indicates that the material selected was really homogeneous and a fair basis for a comparison of the sexes.

2. *Questions on sensory experiences.* — The questions on sensory experiences were as follows:

1. Is any one of your senses notably keen or notably dull?
2. Are you particularly sensitive to impressions derived from any one sense?
3. Do you derive special pain or pleasure from the sense-impressions of any one sense-organ?
4. Have any of your sense-organs had special training?
5. Do musical tones suggest colors to you?
6. Are letters, words, or names colored to you?
7. Have you any color associations with smells or tastes?

The answers to the first four questions are embodied in Table XX. The number of subjects who had received special training of the senses is so

TABLE XX.

Answers to questions 1–4 on sensory experiences.

		Temperature.	Touch.	Taste.	Smell.	Sight.	Hearing.	None.
Senses notably keen.	Women	..	1	..	3	5	4	12
	Men ...	..	..	1	3	4	4	15
Senses notably dull.	Women	..	..	..	2	1	4	18
	Men ...	..	..	1	2	1	3	18
Senses particularly prominent in consciousness.	Women	..	1	..	4	6	3	12
	Men ...	..	..	..	2	5	7	13
Senses a source of special pleasure.	Women	..	1	..	3	10	5	9
	Men ...	1	..	1	2	6	8	10
Senses a source of special pain.	Women	..	1	..	3	4	5	14
	Men ...	1	..	..	1	1	7	15
Senses specially trained.	Women	..	..	..	..	4	9	15
	Men ...	..	..	..	..	2	10	15

nearly identical for the two sexes that training cannot be held responsible for the sense-differences shown by this series of experiments. Fifteen subjects of each sex were without any training, and ten subjects of each sex had been trained. Of the ten women, three had been trained in both sight and hearing, one in sight alone, and six in hearing alone. All of the ten men had been trained in hearing and two of them in both sight and hearing. The table shows that sensory experiences were on the whole somewhat more prominent in the women than in the men. There were more women than men who reported

special keenness of sense, who had some special sense more prominent in consciousness than the others, and who derived special pain and pleasure from simple sensory experiences. The preponderance of women is very small in each case, but is constant. The senses reported particularly keen or dull are almost the same for both sexes. In prominence in consciousness and power to give pleasure or pain we find vision predominating in the women and hearing in the men — results which may be correlated with the women's use of visual imagery and the men's use of auditory imagery, as shown in the memory test (see chap. vii, sec. A).

Pseudo-chromæsthesias proved to be much more frequent among the women than among the men; there were only twelve women who reported none, while there were twenty such men. Among the thirteen women who reported pseudo-chromæsthesias the color association was made in nine cases with musical tones, in four with letters or words, in two with tastes, and in four with odors. None of the color associations of the men were at all fully developed. Of the five who reported them one said it was a discarded habit of which he had not been conscious for several years. Among the other four there were two cases of color association with tones, one with letters, two with taste, and one with smell. Here again we find evidence that visual experience is more important in the consciousness of women than in that of men.

3. *Questions on methods of rest and recreation.* — The questions on methods of rest and recreation were as follows :

1. What way of resting after intellectual work do you prefer?

2. Arrange the following employments in the order in which they give you the most pure pleasure: reading, the theater, the opera, concerts, lectures, social gatherings, outdoor sports, indoor games.

The answers to question 1 are presented in Table XXI. In cases where two or more methods of resting were equally enjoyed by the same subject, all were counted. The difference between the sexes is most apparent in the relative numbers of men and women who preferred sleep and outdoor exercise. The other methods of rest named in the table were about equally prized by men and women.

TABLE XXI.

Answers to questions on preferred methods of resting after intellectual work.

	Modes of Resting.					
	Sleep.	Light reading.	Outdoor exercise.	Social intercourse.	The theater.	Revery.
Women.....	12	5	10	4	2	1
Men.....	8	5	14	5	..	1

The answers to question 2 are formulated in Table XXII. The number of men or women who assigned to a given amusement a given place in the order of their preference is placed under the name of the amusement and opposite the number in the column headed "Order" which indicates the place assigned. Thus, the number of women who assigned the sixth place in the order of their preference to concerts is found under "Concerts," and opposite the 6 in

TABLE XXII.

Order of preference assigned by the subjects to eight amusements.

Order.	Reading.		Theater.		Opera.		Concerts.		Lectures.		Social Gatherings.		Outdoor Sports.		Indoor Games.	
	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.
1	7	4	5	7	8	5	3	0	0	1	1	1	4	9	0	0
2	4	5	7	4	4	5	2	3	2	0	1	3	5	2	0	3
3	5	4	8	5	4	2	4	2	0	1	2	3	2	6	1	3
4	4	5	2	3	5	2	5	1	2	1	3	5	3	4	0	1
5	3	3	1	4	2	3	5	4	0	1	6	5	6	2	1	3
6	2	3	0	3	0	3	6	4	12	7	2	2	2	1	1	2
7	0	1	2	0	2	3	0	7	6	6	8	4	1	0	4	4
8	0	0	0	0	0	2	0	3	2	10	2	0	2	1	15	8

column headed "Order." That number is 6. In case a subject placed two amusements in the same grade of esteem they were tabulated accordingly; and the amusement which the subject placed next after these two was tabulated, not as in the next lowest grade, but as in the next lowest but one. If, *e. g.*, a subject placed reading highest, concerts and the opera next, and social gatherings next, reading would be tabulated as his first choice, concerts and the opera as his second, and social gatherings as his fourth.

It appears from Table XXII that the men's tastes were more evenly distributed than the women's. The women's columns show more large groups and more zeros than the men's.

The order in which the women as a whole and the men as a whole esteemed the amusements in question is given in Table XXIII. From this table it appears that the amusements fall into two groups, each of which was held in the same relative esteem by both the men and the women, though the order of the

TABLE XXIII.

Summation of Table XXII. Order in which the eight amusements were esteemed by the women as a whole and the men as a whole.

Order.	Women.	Men.
1	Opera	Outdoor sports
2	Reading	Theater
3	Theater	Reading
4	Outdoor sports	Opera
5	Concerts	Social gatherings
6	Social gatherings	Concerts
7	Lectures	Indoor games
8	Indoor games	Lectures

amusements within the group differs for the two sexes. The first group consists of reading, the theater, the opera, and outdoor sports; the second of social gatherings, concerts, lectures, and indoor games. The only marked difference in the order of amusements in the two columns of Table XXIII is in the places assigned to the opera and to outdoor sports, which stand respectively first and fourth in the women's list and fourth and first in the men's. It is surprising that social gatherings are placed so low in both scales and that the men gave them a higher preference than did the women.

4. *Questions on the individual aspects of personality.*— The questions on the individual aspects of personality were as follows:

1. Do you consider yourself very emotional?

2. Is your instinct to express emotions or to repress and hide them?

3. What sort of physical expression do violent emotions have?

4. Are you very introspective?

5. Do you do much day-dreaming?

6. Do you ever have illusions, hallucinations, or presentiments?

7. Are you of the impulsive or of the reflective type in action?

8. Do you always give reasons to yourself for your judgments and decisions at the time when you make them, or are they frequently intuitive?

9. Are you very active physically?

10. Are you mechanical? *i. e.*, do you enjoy working with your hands?

11. Have you executive ability? *i. e.*, do you enjoy managing and taking responsibility, and do you succeed when you do?

12. Have you a contented disposition, on the whole?

13. Are you inclined to brood and worry over things which go wrong?

14. Is your impulse to blame yourself if possible, or others if possible, or fate, when things go wrong?

15. Are you very conscientious?

16. Do ethical or æsthetic or religious ideas play the largest part in controlling your acts?

The answers to these questions, with the exception of question 3, are summarized in Table XXIV. The only difference in emotional nature indicated by the answers to the first two questions is a somewhat greater tendency on the part of the women to repress emotions, while the men reported themselves more disposed to express their emotions. In answer to the third question both the men and the women reported trembling as the commonest physical effect of emotion and a tendency to weep as the next commonest. The next in order were rigidity of the muscles and aimless movements in the case of the men, and faintness and weakening in the case of the women. The women mentioned on an average more physical effects of emotion than the men. Whether this fact is due to greater accuracy and completeness on the part of the

TABLE XXIV.

Answers to questions on individual aspects of personality.

	Women.	Men.
1. Emotionality:		
Great	10	10
Medium	5	5
None	10	10
2. Expression or repression of emotion:		
Expression predominant	6	10
Repression predominant	18	15
Neither predominant	1	..
4. Introspectiveness:		
Great	13	13
Medium	6	6
None	6	6
5. Disposition to day-dreaming:		
Great at present	10	8
Great formerly	5	5
Some	7	10
None	3	4
6. Illusions, hallucinations, and presentiments:		
Illusions	1	2
Hallucinations	..	2
Presentiments	13	8
None of the three	12	17
7. Impulsiveness or reflectiveness in action:		
Impulsive	7	9
Reflective	16	15
Neither, primarily	2	1
8. Character of judgments and decisions:		
Reasoned	17	16
Intuitive	7	8
Neither, primarily	1	1
9. Physical activity:		
Great	13	16
Small	12	9
10. Taste for mechanics:		
Great	10	6
Some	2	3
None	13	16
11. Executive ability:		
Marked	13	11
Slight	4	10
None	8	4
12. Habitual contentment:		
Marked	13	18
Slight	3	2
None	9	5

TABLE XXIV—*Continued.*

	Women.	Men.
13. Disposition to brood and worry:		
Marked	9	10
Some	4	6
Very little	12	9
14. Habit as to placing blame for mishaps:[1]		
Disposed to blame self	10	10
Disposed to blame others	6	6
Disposed to blame fate	2	1
Disposed to place blame where it belongs	6	6
15. Conscientiousness:[2]		
Marked	14	14
Some	6	7
None	5	3
16. Standards of conduct:		
Religious	3	3
Ethical	12	11
Æsthetic	5	6
Religious and ethical equally	4	2
Ethical and æsthetic equally	1	3

women, or to a more complicated response to emotion on their part, it is difficult to judge. The result of the plethysmographic test (see above, sec. A) which showed the bodily response of the men to the stimuli used more marked and immediate than that of the women, would point to the former hypothesis. In the only case in which the subjects were questioned as to the physical effects of a particular emotion (viz., the case of question 18, on embarrassment, in sec. 5) more effects per individual were reported by the men.

The tendency to introspection (questions 4 and 5) was reported the same for both sexes, except for a slightly greater tendency toward day-dreaming in the

[1] One man and one woman were unable to answer this question. One man thought himself equally likely to blame himself and others.

[2] In the case of one man this question was omitted.

case of the women. The question on illusions, hallucinations, and presentiments elicited the fact that presentiments were more frequent among the women, while illusions and hallucinations were more frequent among the men. It is interesting to notice in this connection that all subjects who reported either illusions or hallucinations reported presentiments also. The answers regarding impulsiveness (questions 7 and 8) are grouped almost identically for the two sexes. What little difference there is shows less impulsiveness and more tendency to control by reason on the part of the women — a result which is in agreement with their greater tendency to repress and control emotion.

The men reported a more marked tendency to physical activity (question 9) than the women, but the women reported a greater taste for working with the hands (question 10). The former report accords with the popular opinion, but the latter is unexpected. In executive ability (question 11) little, if any, difference between the sexes appears. There are more women at both extremes and more men in the middle range.

There were more men than women who were habitually contented (question 12), but the tendency to worry (question 13) was somewhat greater among the men — a result which seems a little contradictory. The tendency to locate blame for unfortunate events (question 14) is distributed among the various categories in the same proportion for both sexes. The answers to the question on conscientiousness (question 15) coincide almost exactly for the two sexes.

When the last question, as to the nature of the standards of conduct, was asked, it was carefully ex-

plained to the subject that the inquiry was whether his decisions about acts were controlled by considering whether or not the act in question was pleasing to God, or by considering whether the act was right or wrong, or by considering whether it was pleasing and proper and fit under the circumstances. Many subjects answered that more than one of these standards governed their decisions. In such cases, if one of the standards was reported predominant, the subject was classified under that standard alone; but if two were reported equally important, the subject was classified as governed by a combined standard. The men and the women are classified under each standard in about the same proportion, though the æsthetic factor appears more frequently in the men's standards and the religious in the women's. The ethical factor seems equally important to both sexes. The total number of times each of the three standards was mentioned, as either primary or secondary, by the men and the women appears in Table XXV.

TABLE XXV.

Number of times the three standards of conduct were mentioned by the subjects.

	Women.	Men.
Religious	11	8
Ethical	20	17
Æsthetic	7	15

Here the greater prevalence of æsthetic judgments among the men and of religious judgments among the women is more marked, while ethical judgments seem to be slightly more prevalent among the women.

5. *Questions on social aspects of personality.*—The questions on the social aspects of personality were as follows:

1. Are your interests in life centered more largely in your relations with people, or in your intellectual and practical pursuits?
2. Are you sensitive about other people's opinion of you?
3. Do you consider yourself independent in making decisions or are you influenced by the view of others?
4. Do you like to be much alone, or do you desire companionship most of the time?
5. Do you enjoy conversation particularly?
6. Do you enjoy the society of men or of women better?
7. Have you many friends?
8. Have you many intimate friends?
9. Are the majority of your friends men or women?
10. Are you affectionate?
11. Are you sympathetic?
12. Are you demonstrative in affection?
13. Do you attach much importance to relationships, *i. e.*, do you feel under obligation to like a person or to do him favors merely because he is related to you?
14. Are you socially timid?
15. Are you physically timid?
16. Are you frank?
17. Are you easily embarrassed?
18. How does embarrassment show itself?
19. Are you curious about affairs that are not of immediate interest to you?

The summary of the answers to these questions (except the answer to question 18) is given in Table XXVI. The general tenor of the answers is to show that social relationships are more important to the men than to the women. A greater number of the men than of the women reported that they were more keenly interested in their relations with people than in

TABLE XXVI.

Answers to questions on social aspects of personality.

	Women.	Men.
1. Center of interest:		
Other people	14	17
Own pursuits	6	6
Both equally	5	2
2. Sensitiveness to others' opinion:		
Great	10	13
Some	11	8
Slight	4	4
3. Independence in decision:		
Great	11	12
Medium	7	7
Slight	7	6
4. Taste for solitude:		
Great	9	5
Some	10	6
None	6	14
5. Taste for conversation:[1]		
Great	18	16
Small	7	8
6. Preference for society of own or other sex:		
Own	10	8
Other	4	10
No preference	11	7
7. Number of friends:[2]		
Many	15	20
Few	8	5
8. Number of intimate friends:		
Many	12	10
Few	13	15
9. Sex of majority of friends:		
Own	18	13
Other	2	4
No preponderance	5	8
10. Affectionateness:		
Marked	16	18
Medium	4	5
None	5	2
11. Sympathy:		
Marked	18	21
Medium	4	2
None	3	2

[1] In the case of one man this question was omitted.

[2] One woman was unable to answer this question and one reported the number of her friends as medium.

TABLE XXVI—*Continued.*

Answers to questions on social aspects of personality.

	Women.	Men.
12. Demonstrativeness in affection:		
Marked	6	9
Medium	3	6
None	16	10
13. Consideration for relatives as such:		
Great	9	6
Small	11	10
None	5	9
14. Social timidity:		
Marked	13	12
None	12	13
15. Physical timidity:		
Marked	9	9
None	16	16
16. Frankness:[1]		
Marked	11	16
Medium	3	6
None	10	3
17. Liability to embarrassment:		
Marked	15	8
Medium	1	9
None	9	8
18. Curiosity:		
Great	8	10
Small	4	3
None	13	12

their own pursuits; that they were extremely sensitive about other people's opinion of them; that they desired companionship most of the time; and that they had a large circle of friends. Fewer of the men than of the women, however, reported a great number of intimate friends. More of the men than of the women considered themselves affectionate, sympathetic, and demonstrative in affection. Their curiosity appears slightly greater than that of the women.

The interest in the other sex also appears greater

[1] One woman was unable to answer question 16.

among the men than among the women. A considerably greater number of the men than of the women said they enjoyed the society of the other sex better than that of their own, and there were more men than women with an equal or greater number of friends of the opposite sex. As to independence in judgment and action the two records are practically alike. More of the women than of the men laid stress on relationship, a fact which is in accord with the greater prominence of religious and ethical standards among the women. No difference in timidity, either social or physical, was reported. The number of men reporting frankness considerably exceeds the number of women.

More women than men reported themselves easily embarrassed, but the men as a whole reported a greater number of physical effects of embarrassment than the women. For both sexes the commonest effect was blushing and the next some departure from the usual habit of speech. Of these modifications of speech unusual reticence was most frequent in both sexes; getting the tongue twisted or hesitating came next, and unusual talkativeness next Forgetting words and making aimless movements were reported an equal number of times by both sexes. Feeling hot and perspiring were reported frequently by men, but not by women.

6. *Questions on intellectual interests, methods of work, and beliefs.*—The questions on intellectual interests, methods of work, and beliefs were as follows:

1. What lines of study have interested you most?
2. What branches have you found easiest?
3. What branches have you found hardest?

4. In what departments have you done your best work?

5. Have you specialized, and, if so, in what department?

6. Have you a number-form, or diagrams for the days of the week or months of the year?

7. What sort of imagery predominates in your thinking?

8. Do you have a schedule for your hours of study, or do you arrange each day as it comes?

9. How large a proportion of your free time do you spend in study?

10. Do you derive real enjoyment from the study itself, or is it only a means to an end — a necessary drudgery?

11. Have you decided on your career in life? If so, is it to be practical, intellectual, or artistic?

12. Have you strong religious beliefs?

13. Do you adhere to the doctrines of any one church?

14. Have you any belief at all in (*a*) spiritualism, (*b*) telepathy, or (*c*) Christian science?

15. Are you at all influenced by omens or presentiments?

16. Have you any superstitions?

TABLE XXVII.

Answers to questions on intellectual interests.

1. Studies regarded with greatest interest:

Women.	Men.
11. Science.	10. Science.
10. Philosophy.	10. Philosophy.
10. English.	7. History.
8. Modern languages.	6. Ancient languages.
7. History.	5. Modern languages.
6. Ancient languages.	5. Economics.
4. Mathematics.	5. Sociology.
4. Sociology.	5. English.
3. Economics.	4. Mathematics.
	1. No preference.

2. Studies found easiest:

Women.	Men.
11. Modern languages.	12. Modern languages.
10. Ancient languages.	9. Ancient languages.
6. Science.	5. Science.
6. English.	4. History.

TABLE XXVII—*Continued.*

2. Studies found easiest—*Continued:*

Women.	Men.
5. Mathematics.	4. Mathematics.
2. History.	2. Sociology.
2. Philosophy.	1. Philosophy.
1. Economics.	
1. Sociology.	
3. All equally easy.	3. All equally easy.

3. Studies found hardest:

Women.	Men.
6. Mathematics.	12. Mathematics.
6. History.	4. Science.
5. English.	3. Ancient languages.
5. Philosophy.	3. Modern languages.
4. Ancient languages.	3. Philosophy.
3. Science.	2. Economics.
2. Modern languages.	1. History.
1. Economics.	1. English.
3. All equally hard.	2. All equally hard.

4. Studies in which best work had been done:

Women.	Men.
11. Ancient languages.	7. Modern languages.
10. Modern languages.	4. Ancient languages.
5. Mathematics.	4. Philosophy.
5. Science.	4. English.
4. English.	4. History.
3. History.	3. Science.
2. Philosophy.	3. Sociology.
1. Economics.	2. Mathematics.
	2. Economics.
2. Work equally good in all.	2. Work equally good in all.

5. Studies adopted as specialties:

Women.	Men.
5. Modern languages.	5. Economics.
4. Ancient languages.	3. Science.
4. Science.	3. Philosophy.
4. Philosophy.	2. Modern languages.
1. English.	1. History.
1. Economics.	
1. Sociology.	1. Sociology.
10. None.	11. None.

The answers to the first five questions are summarized in Table XXVII. The number before the name of each study indicates the number of times the study was mentioned in the answers as most interesting, easiest, etc.

The most striking thing about this table is the general uniformity in the answers. Both the men and the women reported philosophy and science as the subjects of greatest interest, languages as the easiest and the one in which best work had been done, and mathematics as the hardest. Science, philosophy, and languages occupy closely corresponding positions in the tables of the men and women throughout. The only marked difference in the amount of interest in the various studies reported by the two appears in the greater interest of the women in English. Mathematics was reported as the hardest subject by twice as many men as women, while more of the women than of the men found it easy and reported good work in it. History, while equally interesting to both sexes, appears easier for the men. It is interesting to note that in both cases the subjects which were easiest were also those in which best work was being done. This correspondence is somewhat closer in the case of the women. The studies found easiest by the greatest number of women were also those in which the greatest number of them were specializing—a statement which is not true of the men. The number who had done no specializing was about the same in both sexes.

The outcome of these questions is interesting in its bearing on the test for general information (chap. vii, sec. D). It goes to show that the individuals used for that test were really comparable in amount of training and in interests.

The answers to the remaining questions under the present head are summarized in Table XXVIII.

TABLE XXVIII.

Answers to questions on methods of work and beliefs.

	Women.	Men.
6. Number-forms and diagrams for days and months:		
Present	7	4
Absent	18	21
7. Character of mental imagery:		
Visual	14	15
Motor	4	1
Auditory	2	3
Visual-motor	1	3
Auditory-motor	2	..
Visual-auditory	2	..
Visual-motor-auditory	..	3
8. Use of a schedule of daily work:		
Rigid	10	8
Flexible	3	6
None	12	11
9. Proportion of time given to study:		
All	7	8
More than half	7	9
Half	6	2
Less than half	5	6
10. Manner in which study is regarded:		
As a pleasure	13	11
As drudgery	4	11
Partly as a pleasure, partly as drudgery	8	3
11. Career selected:		
Practical	1	2
Intellectual	14	8
Practical and intellectual	4	13
None yet selected	6	2
12. Religious beliefs:		
Strong	16	10
Some	5	4
None	4	11
13. Adherence to church creeds:		
Some creed adhered to	9	8
None adhered to	16	17
14*a*. Attitude toward spiritualism:		
Belief	1	4
Neutrality	5	5
Disbelief	19	16

TABLE XXVIII—*Continued.*

Answers to questions on methods of work and beliefs.

	Women.	Men.
14*b*. Attitude toward telepathy:		
Belief	10	15
Neutrality	10	4
Disbelief	5	6
14*c*. Attitude toward Christian science:		
Belief	2	3
Neutrality	2	1
Disbelief	21	21
15. Influence of omens and presentiments:		
Some	9	6
None	16	19
16. Superstitions:		
Some	9	7
None	16	18

Number-forms and diagrams for the days of the week and the months of the year are shown by the table to be more numerous among the women than among the men, although the difference is much less marked than it was in the case of the pseudo-chromæsthesias. This again points to the greater prominence of visual experience in women. The answers to the question on the general type of mental imagery, however, do not accord with the previous evidence on the subject. There are more men than women who report that visual or visual-motor imagery predominates in their thinking. The memory test and the questions on sensory experience would have led us to expect auditory imagery to be more common among the men than among the women, but the answers to the question on imagery do not bear out this expectation. Since a general question on the type of imagery is so difficult for those comparatively unskilled in introspection to answer accurately, per-

haps in this case the special pieces of evidence are more to be trusted than the general answer.

The only marked sex-difference revealed by the questions on methods of study (8-10) is that the women on the whole derive more pleasure from the study itself, while to the men it is more likely to be a means to an end. They seem about equally inclined to be systematic in the disposition of time. There is a slight predominance of women with rigid schedules, and of men with flexible schedules. The men report a somewhat larger proportion of free time spent in study than the women—a result which is contrary to the popular opinion on the subject. The answers regarding the selection of a career indicate chiefly the fact that over half of the women were planning to teach —an occupation which they classed as intellectual— while about the same number of men were preparing for courses in either law or medicine—professions which are classified as intellectual and practical. There were none who expected to devote themselves to art in any form.

The questions on beliefs (12-16) revealed a somewhat greater tendency on the part of the women to have strong religious beliefs and to be affected by omens and superstitions; and, on the part of the men, a more marked tendency to believe in spiritualism, telepathy, and Christian science.

SUMMARY OF OTHER EXPERIMENTAL WORK ON AFFECTIVE PROCESSES.

Before bringing together what little experimental material there is on the subject of the affective aspect of consciousness as it appears in men and women, it

may be well to emphasize still further the extremely unsatisfactory nature of both methods of investigating affective processes employed in the present work. One of them — the questionnaire — is only semi-scientific, while the other — the method of expression — has as yet developed no standard for evaluating the results. The mere personal answer to a question about matters of temperament and disposition, or even about intellectual characteristics, is far from approaching the value of a scientific fact. In fact, such personal estimates are peculiarly liable to perversion for obvious reasons. The method of expression, while it holds forth some hope that it may some day lead to the discovery of a constant correlation between affective states and certain involuntary movements — particularly those of circulation — has not as yet given us any trustworthy criterion for interpreting results. Recognizing fully the serious criticisms to be passed on the methods employed, the results are given not as scientifically determined facts, but as constituting the only indication of probabilities which we have at present.

The few previous experiments on record regarding the affective processes which have any bearing on the present series relate, first, to synæsthesia; second, to one of the individual aspects of personality; third, to the relative use of visual imagery by men and women; and, fourth, to beliefs.

1. Several experiments on synæsthesia of various forms agree in showing this experience to be more frequent among women than among men. Galton (26) found that number-forms were twice as numerous among women as among men. Chalmers (17) finds number-forms more frequent among female students

than among male. Krohn (44) says that the greater number of his cases of pseudo-chromæsthesia were among women. Miss Calkins (14, 15) found that a very high percentage (50) of the women she examined had synæsthesias, but she furnishes no data for a comparison with men.

2. In the data collected at Wellesley College from Wellesley and Harvard students (45) it appeared that a larger proportion of the women examined were inclined to day-dreaming than of the men. This fact accords with the results of question 5 of sec. 4, above.

3. The Columbia University tests (82) included a question as to the kind of mental imagery chiefly employed by each subject. This question, like the same one in the present series (question 7 of sec. 6), revealed no greater use of visual imagery by the women as against the men. Likewise Miss Calkins (12) found practically no difference between men and women in the tendency to visualize numerals. On the other hand Galton (26) came to the conclusion that women have more vivid visual imagery than men. Since his subjects were gathered miscellaneously, they were not as comparable in this respect as university students.

4. Sumner (77) using a questionnaire on belief, found belief in presentiments, omens, and superstitions more prominent among women than among men —a result in agreement with that of questions 15 and 16 of sec. 6, above.

GENERAL SUMMARY OF EXPERIMENTS ON AFFECTIVE PROCESSES.

The physiological expression of affective processes, as shown in the experiments on circulation and respiration, is more intense in men than in women. As to

the character of the affective processes themselves, the most striking thing revealed by the above questions on personality is their close coincidence in both sexes. The realm of feeling is one of those upon which chief stress is laid by those who believe that there are important psychological differences of sex, and yet we find a series of men and a series of women reacting toward questions about the life of feeling in wonderfully similar ways. Nevertheless, a few differences are revealed, some of which confirm certain conclusions suggested by previous experiments of the present series.

Sensory experience in general seems to be somewhat more prominent in the consciousness of women than in that of men. Other investigators agree that synæsthesias occur more frequently in women than in men, and in the present investigation they were found (grouping all forms together) in fifteen women and eight men. This fuller sensory experience of women may be correlated with the fact that their senses as a whole are more highly developed. The greater prominence of visual consciousness among women is especially marked. That women's visual consciousness held this relative position was suggested by their better-developed sense of color, their more frequent use of visual images in memorizing, and their greater readiness in solving a problem depending on quickness of visual perception. This suggestion receives further confirmation from the fact that a greater number of women than of men report vision as the sensory field which attracts attention most readily, and as the one from which most pleasure and pain are derived. Pseudo-chromæsthesias, number-forms

and diagrams for the days of the week and months of the year are also more numerous among women than among men. The pseudo-chromæsthesias may be correlated with the more highly developed color sense of women.

The greater motor ability of men, which was shown by the experiments recorded in chap. ii, may be correlated with the answers to the questions on methods of rest and recreation and the question as to physical activity. More men than women prefer outdoor exercise as a method of resting after mental work. Men class outdoor sports much higher than do women as a form of amusement. Physical activity is greater among men than among women.

Social consciousness seems to be more prominent in men than in women. Social gatherings are ranked higher, as a form of amusement, by men, and their immediate relations to their fellows seem to be of greater importance to men than to women.

The religious consciousness is more prominent among women than among men. More women than men have strong religious beliefs and regulate their actions by religious standards. Belief in omens, presentiments, and superstitions is also somewhat more prominent among women.

As far as the strength of the emotional nature, the form of its expression, and the degree of impulsiveness in action are concerned, the answers coincide very closely for the sexes. The only difference is that women seem to have a greater tendency to inhibit the expression of emotion and to act from reason rather than from impulse. The tendency to introspection is the same for both sexes. It is somewhat more apt to

take the form of day-dreaming among women. The reports on conscientiousness are the same for both. Men are more frank than women, and women are more easily embarrassed than men. In intellectual interests, easiest and hardest branches of study, and methods of work, there are only trifling divergences. Women derive more pleasure from study than men, while men devote somewhat more time to it than women.

CHAPTER IX.

CONCLUSION.

In the previous chapters the separate divisions of conscious processes, motor ability, the various sensory fields, intellectual faculties, and the affective processes have been considered singly with reference to their comparative development in men and women. We may now bring together the results obtained from the various fields, and ascertain whether or not any broad generalizations with reference to the psychological norms of men and women which can be regarded as of fundamental importance have been reached.

It has been found that motor ability in most of its forms is better developed in men than in women. In strength, rapidity of movement, and rate of fatigue, they have a very decided advantage, and in precision of movement a slight advantage. These four forms of superiority are probably all expressions of one and the same fact—the greater muscular strength of men. In the formation of a new co-ordination women are superior to men. The greater muscular strength of men is a universally accepted fact. There has been more or less dispute as to which sex displays greater manual dexterity. According to the present results, manual dexterity which consists in the ability to make very delicate and minutely controlled movements is slightly greater in men; that which consists in the ability to co-ordinate movements rapidly to unforeseen stimuli is clearly greater in women.

There have been two opposing views on the general subject of the sensibility of the sexes; one assigning the keener senses to men, and the other to women. They have been based either on inadequate experiment in a few fields of sensibility or on general theoretical considerations. The present investigation of the total field of sensibility has resulted in the following conclusions regarding thresholds and discriminative sensibility:

Thresholds.—Women have lower thresholds in the recognition of two points on the skin; in touch; in sweet, salt, sour, and bitter taste; in smell; in color; and in pain through pressure. Men and women are alike in respect to the upper and lower limits of pitch. Men have a lower threshold in the perception of light.

Discriminative sensibility.—Women have finer discrimination in pitch and in color. Men and women have equal discrimination in temperature, in odor, and in passive pressure. Men have finer discrimination in lifted weights; in sweet, sour, and bitter taste; in shades of gray; probably in areas on the skin (the test on this subject does not warrant certainty); and in visual areas.

The number of cases in which the advantage is on the side of the women is greater than the number of cases in which it is on the side of the men. The thresholds are on the whole lower in women; discriminative sensibility is on the whole better in men. Those sensory judgments into which sensations of movement enter directly, such as the discrimination of lifted weights and of visual lines and areas are somewhat better in men. All these differences, however, are slight.

As for the intellectual faculties, women are decidedly superior to men in memory, and possibly more rapid in associative thinking. Men are probably superior in ingenuity. In general information and intellectual interests there is no difference characteristic of sex.

The data on the life of feeling indicate that there is little, if any, sexual difference in the degree of domination by emotion, and that social consciousness is more prominent in men and religious consciousness in women.

Let us now turn to the question how well or how ill these results accord with the prevailing biological view of the mental differences between the sexes.

It is perhaps not fair to speak of a prevailing view in a question regarding which dispute is so rife; but the view which seems to command the adherence of most scientists at present is that advanced by Geddes and Thomson (29). It is worked out in some detail on the psychological side by Fouillée (25); Brooks (10) and Patrick (68) represent the same tendency. The view is not altogether free from contradictions, nor entirely satisfactory in so far as it pretends to be a theory of the evolution of sex. Leaving these points aside, its general tenets are that the differentiation between the sexes in the course of evolution has been in the direction of a sort of division of labor, the male assuming the processes of nutrition and the female those of reproduction, which has made women more anabolic and men more catabolic in physiological structure. This difference is displayed in its most elementary form by the two sexual cells. The female is large and immobile. It represents stored nutrition.

The male cell is small and agile. It represents expenditure of energy. From these fundamental characteristics the social and psychological differences can be deduced. The female represents the conservation of the species — the preservation of past gains made by the race. Her characteristics are continuity, patience, and stability. Her mental life is dominated by integration. She is skilled in particular ideas and in the application of generalizations already obtained, but not in abstraction or the formation of new concepts. Since woman is receptive, she possesses keener senses and more intense reflexes than man. Her tendency to accumulate nutrition brings about a greater development of the viscera, and, since emotions are reflex waves from the viscera, woman is more emotional than man. The male, on the other hand, represents the introduction of new elements. Males are more variable than females throughout the animal kingdom. Everywhere we find the male sex adventurous and inventive. Its variety of ideas and sentiments is greater. Its activities are characterized everywhere by impulsiveness and intensity, rather than by patience and continuity. Men are more capable of intense and prolonged concentration of attention than women. They are less influenced by feeling than women. They have greater powers of abstraction and generalization.

It is evident that, on the surface at least, the results at which we have arrived accord very well with this theory. Men did prove in our experiments to have better-developed motor ability and more ingenuity. Women did have somewhat keener senses and better memory. The assertion that the influence of emotion

is greater in the life of women found no confirmation. Their greater tendency toward religious faith, however, and the greater number of superstitions among them, point toward their conservative nature—their function of preserving established beliefs and institutions.

But before we accept the theory advanced as the correct interpretation of the facts, it would be well to examine a little more closely the evidence on which it rests, and consider whether or not there is any other possible interpretation with equal claims to a hearing.

In the first place, this theory, in so far as its deductions about mental characteristics are derived as necessary conclusions from the nature of the genital cells, seems to rest on somewhat far-fetched analogies only. The sets of characteristics deduced for the sexes may be correct, but the method of deriving them is not very convincing, nor is the set of characteristics derived for each sex entirely consistent. Women are said to represent concentration, patience, and stability in emotional life. One might logically conclude that prolonged concentration of attention and unbiased generalization would be their intellectual characteristics. But these are the very characteristics assigned to men. Women, though more stable in their emotions, are more influenced by them, and, although they represent patience and concentration, they are incapable of prolonged efforts of attention. Men, whose activity is essentially intermittent, and whose emotions are greater in variety and more unstable, are characterized by prolonged strains of attention and unbiased judgment. It may be true, but the proof for it does not appeal to one as very cogent. In fact, after reading the several expositions of this theory, one is left

with a strong impression that, if the authors' views as to the mental differences of sex had been different, they might as easily have derived a very different set of characteristics. There is truth as well as humor in Lourbet's (52, chap. vi) suggestion that, if the nature of the genital cells were reversed, it would be a little easier for this school of evolutionists to derive the characteristics of sex with which they finally come out. In that case, the female cell, smaller and more agile than the male, would represent woman with her smaller size, her excitable nervous system, and her incapacity for sustained effort of attention; while the male cell, large, calm, and self-contained, would image the size and strength, the impartial reason, and the easy concentration of attention of men.

The fact which is put forward to prove the greater natural ingenuity and inventiveness of man is his greater variability. Lombroso, without more ado, asserts that the male is everywhere, and in all respects, more variable than the female, and that this fact alone is sufficient to prove his greater creative ability. The doctrine has been unquestioningly adopted by all the advocates of this theory. It is called upon to explain the occurrence of more individuals of unusual mental capacity, both above and below the norm, as well as to account for the greater versatility and inventiveness of the male mind.

Unfortunately for the theory, the latest researches on the question of variability have failed to sustain it. Pearson (69) subjects the previous methods of measuring variability to criticism, and finds them very faulty. He insists that pathological variations are not a fair test of average variability in the sexes, because many

diseases have a tendency to attack one sex rather than the other. The true measure of the variability which must be regarded as important in evolution is, he says, the amount of normal variation found in organs or characteristics not of a secondary sexual character. The variation, however, of any organ must be judged by its relative departure from its mean, not, as has formerly been done, by its absolute variation, or by its variation relatively to some other organ. Taking all the available physical measurements of human beings as a basis for his calculation, Pearson finds the total trend of his observations to be toward a somewhat greater tendency to variation in women than in men. He concludes that "the principle that man is more variable than woman must be put aside as a pseudo-scientific superstition until it has been demonstrated in a more scientific manner than has hitherto been attempted."

While it may still prove true that men are intellectually more variable than women, it cannot be deduced directly from the universally greater variability of man. The fact is often held to be proved from the greater prevalence of both genius and imbecility among men, but, as Pearson points out, these are both forms of abnormal variation. It is perfectly conceivable that the class which presented the greatest number of abnormalities in a character might not be the class which displayed the widest normal variations of that character.

But even though it could be shown that men are intellectually more variable than women, it is still difficult to see why this would give a basis for the statement that inventiveness and ability to arrive at

new generalizations are characteristic of the male mind as opposed to the female. It would, if true, lead us to expect a greater number of intellectually inferior and of intellectually superior individuals belonging to the male sex. In so far as great originality is characteristic of exceptional mental ability, it would lead us to expect that the greatest discoveries and inventions should come from these exceptional individuals. But that is not at all the same thing as saying that originality and inventiveness are characteristic of the male mind as a whole, in opposition to the female mind, as a whole. This statement assumes not merely greater variability of mind in general, but the presence of a variation in a given direction.

The biological theory of psychological differences of sex is not in a condition to compel assent. While it is true, therefore, that the present investigation tends to support the theory, it is just as true that the uncertain basis of the theory itself leaves room for other explanations of the facts, if there are other satisfactory ways of explaining them.

In considering the question whether or not there is any other explanation for the facts in the case, it is important to remember that the make-up of any adult individual cannot be attributed entirely to inherited tendency. The old question of the relative importance of heredity and environment in the final outcome of the individual must be taken into consideration. Although the timeworn controversy is far from satisfactory settlement, the results of recent observation on individual development have tended to emphasize more and more the extreme importance of envi-

ronment. The sociological experiments in which very young children from the criminal classes have been placed in good surroundings, with no knowledge of their antecedents, have shown that such children usually develop into good members of society. The entire practical movement of sociology is based on the firm conviction that an individual is very vitally molded by his surroundings, and that even slight modifications may produce important changes in character.

The suggestion that the observed psychological differences of sex may be due to difference in environment has often been met with derision, but it seems at least worthy of unbiased consideration. The fact that very genuine and important differences of environment do exist can be denied only by the most superficial observer. Even in our own country, where boys and girls are allowed to go to the same schools and to play together to some extent, the social atmosphere is different, from the cradle. Different toys are given them, different occupations and games are taught them, different ideals of conduct are held up before them. The question for the moment is not at all whether or not these differences in education are right and proper and necessary, but merely whether or not, as a matter of fact, they exist, and, if so, what effect they have on the individuals who are subjected to them.

The difference in physical training is very evident. Boys are encouraged in all forms of exercise and in out-of-door life, while girls are restricted in physical exercise at a very early age. Only a few forms of exercise are considered lady-like. Rough games and violent exercise of all sorts are discouraged. Girls

are kept in the house and taught household occupations. The development of physical strength is not held up to girls as an ideal, while it is made one of the chief ambitions of boys.

While it is improbable that *all* the difference of the sexes with regard to physical strength can be attributed to persistent difference in training, it is certain that a large part of the difference is explicable on this ground. The great strength of savage women and the rapid increase in strength in civilized women, wherever systematic physical training has been introduced, both show the importance of this factor. When we consider other forms of motor ability than mere muscular force, such as quickness of reaction and accuracy of co-ordination, it seems very probable that mere differences of physical training are ample to account for these differences of sex. While it seems to be true that slower rates of movement and decreased accuracy of co-ordination do result from greatly inferior physical strength it is not true that the correlation is quantitatively a close one. Even with wide differences in muscular force, the difference in motor ability is comparatively slight. Where the differences in strength are slight, we have no reason to expect differences in motor ability on that ground.

When we consider the other important respect in which men are supposed to be superior to women — ingenuity or inventiveness — we find equally important differences in social surroundings which would tend to bring about this result. Boys are encouraged to individuality. They are trained to be independent in thought and action. This is the ideal of manliness held up before them. They are expected to under-

stand the use of tools and machinery, and encouraged to experiment and make things for themselves. Girls are taught obedience, dependence, and deference. They are made to feel that too much independence of opinion or action is a drawback to them — not becoming or womanly. A boy is made to feel that his success in life, his place in the world, will depend upon his ability to go ahead with his chosen occupation on his own responsibility, and to accomplish something new and valuable. No such social spur is applied to girls. Royce (73) in his article on the psychology of invention says:

> Only heredity can account for the very wide differences between clever men and stupid men, or explain why men of genius exist at all. But the minor and still important inventiveness of the men of talent, the men of the second grade, is somehow due to a social stimulation which sets their habits varying in different directions. And this stimulation is of the type which abounds in periods of individualism. . . . . For once more, the primary character of the social influences to which we are exposed is that, within limits, they set us to imitating models; they tend to make us creatures of social routine, slaves of the mob, or obedient servants of the world about us. . . . . Inventions thus seem to be the results of the encouragement of individuality.

If one applies these words to the question of the relative inventiveness of the sexes, and realizes the wide differences in social influence which still exist even in a community where women have more freedom and more education than anywhere else in the world, it seems rash to assume that the observed difference in inventiveness represents a genuine and fundamental sexual difference of mind. The fact that the difference revealed by experiment is so slight in men and women whose educations have been as nearly

alike as those of students in a co-educational university, tends to throw further doubt on the fundamental importance of this distinction. The very brief period in which women have been given any systematic education, or any freedom of choice in occupation, makes it impossible to decide the question on the basis of previous achievement.

The same social influences which have tended to retard the development of motor ability and of inventiveness in women would tend to develop keenness of sense and the more reproductive mental processes, such as memory. The question is largely one of the distribution of attention. A large part of a boy's attention goes toward his activities — the learning of new movements, the manipulating of tools, the making of contrivances of various sorts. A girl's less active existence must be filled with some other sort of conscious process. The only possibility is that sensory and perceptual processes should be more prominent. In some cases the special training of girls tends directly toward the development of a special sense. This is notably true in color, and perhaps has some influence in taste. On the more purely intellectual level, it is only natural that in the absence of a sufficient social spur toward originality and inventiveness, they should depend more upon memory for their supply of ideas. It is easier for any individual to learn some one else's ideas than to think out his own. Every teacher has to struggle against the tendency to memorize merely, and to endeavor in every way to stimulate original thought and help pupils to form the habit of doing their own thinking. It is no great matter for surprise that in the absence of social stimulus toward originality of

thought, women should have tended, from inertia, to stay in the realm of reproductive thinking.

It will probably be said that this view of the case puts the cart before the horse—that the training and social surroundings of the sexes are different because their natural characteristics are different. It will be said that a boy is encouraged to activity because he is naturally active—that he is given tools instead of a doll because he is naturally more interested in tools than in dolls. But there are many indications that these very interests are socially stimulated. A small boy with an older sister and no brothers is very sure to display an ambition to have dolls. It is in most cases quenched early by ridicule, but it is evident that a boy must be taught what occupations are suited to boys. The sorrows of a small girl with brothers because she is not allowed to run and race with the boys and take part in their sports and games have frequently been recounted. If it were really a fundamental difference of instincts and characteristics which determined the difference of training to which the sexes are subjected, it would not be necessary to spend so much effort in making boys and girls follow the lines of conduct proper to their sex. The more probable interpretation of the facts is that the necessities of social organization have in the past brought about a division of labor between the sexes, the usefulness of which is evident. Social ideals have been developed in connection with this economic necessity, and still persist.

This is not the place to discuss the question whether or not the conditions of social organization still demand the same division of labor, and make the preservation of the traditional ideals for the sexes

necessary to the good of society. If such is the case, there is no doubt that the present state of affairs will persist. There are, as everyone must recognize, signs of a radical change in the social ideals of sex. The point to be emphasized as the outcome of this study is that, according to our present light, the psychological differences of sex seem to be largely due, not to difference of average capacity, nor to difference in type of mental activity, but to differences in the social influences brought to bear on the developing individual from early infancy to adult years. The question of the future development of the intellectual life of women is one of social necessities and ideals, rather than of the inborn psychological characteristics of sex.

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